THE OLD ASHMOLEAN

THE OLDEST MUSEUM FOR THE HISTORY OF THE NATURAL SCIENCES AND MEDICINE

BY

R. T. GUNTHER

OXFORD UNIVERSITY PRESS

PRINTED TO BE SOLD AT THE MUSEUM

1933

UNIVERSITY OF OXFORD

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Prepared for the
250th Anniversary of the
opening of the Museum

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PREFACE

Since the publication of *Historic Instruments for the Advancement of Science* in 1925, of which this is an enlarged edition, several notable accessions have shifted the focus of interest of the Museum from the foundation collection of scientific instruments, given by Dr. Lewis Evans, and have made it possible to establish for the first time a **Museum of Historic Museums**. We believe this to be a new departure.

So that now in the Old Ashmolean Building, in the very room opened as a Museum 250 years ago, we show Museums of Natural History and Medicine of the seventeenth and eighteenth centuries, as well as Collections of Philosophical Apparatus, as scientific instruments were then called, of the seventeenth, eighteenth, and nineteenth centuries.

To the numerous friends who have enabled me to bring such a unique exhibition together in the Old Ashmolean, my best thanks.

At the same time we have not forgotten our paramount duty to exhibit the work of local men of science, be they of the Town or of the Gown. And where possible we have endeavoured to show, side by side, the portrait and handwriting of the man, to give a human interest to his instrument or invention.

More particularly is it the privilege of a Science

Museum to do posthumous honour to those humble inventors who died poor, that their country might wax great in culture and civilization, and to those by whose discoveries the causes of maladies that afflict mankind may be detected, and suffering may be alleviated. Many such had but scant reward in their lifetime. Is it not the duty of a University Museum to succour the waifs and strays of their apparatus, and to safeguard the first-hand evidences of their work, as an incentive to posterity?

R. T. GUNTHER.

THE OLD ASHMOLEAN.

THE OLD ASHMOLEAN BUILDING

SHMOLE'S intentions in founding his Museum are best stated in his own words:

'Because the knowledge of Nature is very necessarie to humaine life, health and the conveniences thereof, and because that knowledge cannot be soe well and usefully attain'd, except the history of Nature be knowne and considered; and to this, is requisite the inspection of particulars, especially those as are extraordinary in their Fabrick, or usefull in Medicine, or applyed to manufacture or trade. I Elias Ashmole, out of my affection to this sort of Learning, wherein myselfe have taken, and still doe take the greatest delight; for which cause also, I have amass'd together great variety of naturall Concretes and Bodies, and bestowed them on the University of Oxford, wherein my selfe have been a student, and of which I have the honor to be a Member.'

A condition made by the founder was that the University should build a house for his treasures.

And since the Natural History specimens to which Ashmole refers had been almost entirely collected by the Tradescants and had been on

exhibition in their historic museum in London from 1634 to 1662, his gift to Oxford had a scientific importance which entitles the Old Ashmolean to be termed the first public Museum of Natural History in Britain.

The story of how the Tradescant rarities came to be acquired, of how they were brought to Oxford by Cully, a Thames bargee, and of how they were finally thrown open to the public on May 21, 1683 by the Duke and Duchess of York and the Princess Anne with speeches and a banquet, has often been told.

But the Ashmolean Building was designed to provide far more than a repository for 'Mr. Ashmole's rarities'.

During the preceding two decades, the prestige of the study of the Natural Sciences, the royal study, stood higher in Oxford than at any other period of her history; but there was no centre for scientific studies and meetings in the University, nor was there any University Laboratory for the performance of chemical and physical experiments. The members of the Oxford Experimental Philosophical Clubbe, or Philosophical Society, needed a permanent house.

The plan for such a College of Science had already been considered in London. Henry Howard, realizing the advantages that would accrue from the possession of a permanent home, gave to the Royal Society a site in Arundel Gardens to build a College for themselves; and Hooke and Wren were invited to thrash out the first details of a plan. At that time Wren was engaged upon his first great building in Oxford, the Sheldonian Theatre, and his ideas for a Scientific Institution were probably framed on a large scale. Anyhow his first scheme appeared 'too chargeable a design'

to Howard; but the latter was soon talked round, 'acquiesced in the reasons', and 'enjoyned' Wren to send an account of his proposals to the Royal Society. Wren wrote from Oxford:

'It contains in the foundations, first, a cellar and a fair laboratory; then a little shop or two, for forges and hammer-works, with a kitchen and little larder. In the first story it contains a vestibule, or passage-hall, leading through from both streets; a fair room for a library and repository, which may well be one room, placing the books after the modern way in glass presses; or, if you will divide the room with pillars, it will the better support the floor of the great room above it, and so place the presses for rarities in the other. Upon the same floor is a parlour for the housekeeper, and from the vestibule the great stairs lead you up to the ante-chamber of the great room, and not higher.

'The great room for the meeting is 40 feet long, and two stories high, divided from the ante-chamber by a skreen between columns, so that the whole length, in case of an entertainment, may be 55 feet. Upon the same floor is the Council-room, and a little closet for the Secretary. . . .'

Wren's College of Science was never built in London: it proved too costly. But Ashmole, as one of the original Fellows of the Royal Society and a friend of Wren and Evelyn, would have been conversant with their ideas for the building.

At Oxford Wren had already recognized the suitability of the vicinity of the Sheldonian Theatre and Bodleian Library for a Museum, for he had himself chosen a wall that he built on the west side of the Theatre yard as suitable for the display of the Arundel Marbles, that had been given, perhaps at the suggestion of Evelyn, to Oxford by Henry Howard. Engravings of both wall and marbles appeared on the title-pages of books printed in the Sheldonian; and later on Charles II 'was pleased to spend some time in viewing the *Marmora Oxoniensia* on the walls of

the Theatre yard'. The niches of this, our oldest *Open-Air Museum* can still be seen under the coping and flaming urns on Wren's well-proportioned wall.

When a site for the Ashmolean 'Repository' and Scientific Institution was required, what was more natural than that it should be chosen next to Wren's Theatre?—a site which Wren must have seen daily from the scaffolding of his growing building. And again, what was more natural than that Wren's ideas for a scientific institution should also have been adopted? or that he should have been consulted when a portion of his new wall on one side of the Theatre yard, had to be removed to make room for the new building?

As executed, the Old Ashmolean embodied all the more important features of Wren's plan—the laboratory in the foundations—the 'little shop or two'—the entry from both streets—the 'fair room' on the first floor—'the great stairs'—the 'great room' above—the 'Council-room and a little closet for the Secretary'—but all simplified, and not so 'chargeable' as was the earlier scheme. And lastly there is the otherwise extraordinary coincidence that whereas Wren specified that his Great room 'may be 55 feet' long, the actual length of the great room of the Old Ashmolean is 56 feet.

A good description of the building appeared within a year of the opening, printed in Chamberlayne's *Anglia Notitia* for 1684:—

'The *Musaeum*, a large and stately Pile of squared Stone, was built in order to the promoting, and carrying on with greater ease and success, several parts of useful and curious Learning, for which it is so well contrived and designed.

'It borders upon the west end of the Theatre, having a very magnificent Portal on that side

sustained by pillars of the Corinthian Order with several curious frizes, and other artificial embellishments. The Front about sixty Feet is to the Street, northward, where is this inscription over the entrance in guilt Characters, *Musaeum Ashmoleanum, Schola Naturalis Historiae, Officina Chimica.*[1] The first foundation was laid on the 14th of April 1679, and it was happily finished on the 20th of March 1683, at which time a rich and noble Collection of Curiosities, was presented to the University by that excellent and publick-spirited Gentleman, Elias Ashmole Esquire, a person so well known in the world that he needs no further elogium here.

'The building consists of ten rooms, whereof the three principal and largest are public, being each in length about 56 feet and in breadth 25.

'The uppermost is properly the *Musaeum Ashmoleanum,* where an inferior officer always attends to show the rarities to strangers.

'The middle room is the *School of Natural Historie,* where the professor of chymistry, Dr. *Plot,* reads three times a week.

'The lower room, to which there is a descent by a double pair of stairs, is the *Laboratory,* perchance one of the most beautiful and useful in the world, furnished with all sorts of furnaces and all other necessary materials. . . . Neare adjoyning to the laboratory are two fair rooms, whereof one is designed for a *Chymical Librarie.*

'Neare the *Musaeum* is a handsome roome fitted for a *Library of Natural History and Philosophy.*

'The other remaining rooms are the lodging chamber and studies of the keeper of the *Musaeum,*

[1] Nail-holes in the architrave over the north door still show where the inscription was fixed, perhaps until 1860 when scientific exhibits were removed from the building.

whereof one, which is most convenient, is sometimes employed and made use of for private courses of Anatomy.'

In the design of a public gallery or Museum, the primary object to be kept in view is the attraction of visitors. This may be done by a façade that promises impressive contents; and it may be achieved with a great welcoming doorway. Wren, as usual, grasped this essential, and the result is the superb portal that none, surely, have ever passed without feeling drawn to enter. Its wide-spreading arched canopy, borne on coupled columns, is more like the interior canopy over an altar or shrine than a canopy over a doorway. But the result gives great dignity to the entrance, while the narrowing flight of steps and the increasing richness of the decorations inwards attract the eye, and so the mind, to enter. Above the porch the façade is decorated with two large panels of pendent shells from overseas, for which the design, it is suggested, may have been supplied by Grinling Gibbons. The actual carving was done by the Oxford monumental mason, T. Wood, who superintended the constructional stonework. Above all is a pediment including the royal arms, with the lilies of France as the first quartering.

That Wood was not the 'architect' of the building, as some have stated, is clearly shown by contemporary University Accounts. Those who have considered him to be so, have been misled by a title erroneously cut below a rare engraving by Burghers that may have been based on working drawings supplied by Wood. The architecture is really based on Serlio's account of that of the Pantheon in Rome, which doubtless Wood was ordered to follow—and very well he did so. A

copy of the book was kept in the Old Ashmolean Library for many years.

The segmental and triangular pediment *motifs* of the east front are repeated alternately, but on a smaller scale, over the heads of all the ten openings in the north front of the building. This is in accordance with a practice common at the period, and it is possible that this front was designed first, and that its simple style was then elaborated for the extra decoration of the eastern end. Sir Reginald Blomfield, after carefully examining the building to test its suitability as an adjunct to the Bodleian Library, even went as far as to suggest that it was of two dates; but he had not noticed that the fine entablature on the east front is repeated at the other end of the building, showing east, west, and north sides to be all contemporaneous. The west end of the Old Ashmolean originally stood out clear, as many old engravings show, but in 1854 it was concealed by a new building erected by Exeter College. The north front is certainly in a more traditional manner than the east end, though this impression is partly given by the retention of transomed windows.

At first, a second doorway in the north side was approached from Broad Street by a flight of steps, which, however, has long been removed, the doors being enclosed by a small balcony without; and over the door-head is the monogram of Charles II, as designed by Wren for the Sheldonian. Round the roof a balustrade matches the balustrade over the Sheldonian, and, in front, Wren's railings, with their grotesque stone terms, reminiscent of the 'Persians' projected by Inigo Jones and Webb for the Court of that name in Whitehall, are continued to the walls of Exeter College.

As to the woodwork, we should have liked more

precise detail than is contained in the building accounts. Mr. Frogley was master carpenter, and with him were associated W. Longe, carpenter; John White, carpenter; and J. Wild, the joiner.

Payments made were to Frogley, £288 0*s.* 9*d.* in 1680–81, £282 3*s.* 3*d.* in 1682, and to Longe and White, £23 14*s.* 7*d.* in 1683. Wainscoting for the rooms was supplied by Wild at a cost of £60 in 1682, and of £110 in 1683, and it lasted until well on into the nineteenth century, for it is shown in a print of Professor Buckland lecturing on geology to a singularly apathetic audience. Why or when it was stripped from the walls we do not know. It is not improbable that Wild also made the doors.

The ironwork throughout the building was uniformly of an exceptionally high standard of craftsmanship. Figures published in *Country Life* speak for the artistic merit of the old locks and bolts, which are still in as good working order as when they were made, after more than two hundred and forty years of wear.

How pleased John Evelyn would have been to find that the kind of work he praised has so satisfactorily stood the test of time. Under date July 16th, 1654, he wrote in his 'Diary,' that in Sir John Glanville's house he—

'was shown such a lock for a door, that for its filing and rare contrivances was a masterpiece, yet made by a country blacksmith . . . and not many years after, there was nothing more frequent than all sorts of ironwork more exquisitely wrought and polished than in any part of Europe, so as a door-lock of a tolerable price was esteemed a curiosity even among foreign princes.'

Honour be to whom honour is due. In 1683 locks and bolts were provided by 'Burrows, ye Ironmonger' for £5 10*s.*, and a lock and keys were bought by Dr. Plot for £7 3*s.* 8*d.* Unfortunately we do not know which locks were provided by each. The work on the lock on the north door is wholly admirable. The craftsman who made it deserves to be remembered.

The external ironwork was wrought by Young, 'ye smith of Oxford', who, in 1680, received £24 7*s.* 7*d.* for

'ironwork about Dr. Ashmole's Repository', and, again, in 1683, received £39 11*s.* 5*d.* for 'Casements, the Iron Gate and other works.

The first two Keepers, PLOT and LHWYD, were scientific men, and certainly under the former the Ashmolean was the centre of scientific studies in Oxford, as the transactions of the PHILOSOPHICAL SOCIETY abundantly show. The Museum received many gifts of importance, notably the Natural Rarities collected by Dr. MARTIN LISTER and Dr. POUND. But during the eighteenth century, though a certain amount of teaching was done, a period of neglect ensued, which was only terminated in the nineteenth by the beneficent activities of the brothers Duncan. The elder, JOHN SHUTE DUNCAN, was Keeper from 1823 to 1829, when he was succeeded by his brother PHILIP. Under their régime the Museum was once more remodelled upon scientific lines, and was reckoned among the leading institutions in which systematic zoology was taught by well-ordered collections. It was a great period of revival in the History of Oxford Science. The prolific researches and teaching of BUCKLAND, DAUBENY, RIGAUD, BADEN POWELL, and KIDD will always be memorable. In their time the Museum gave birth to a second scientific Society, the ASHMOLEAN SOCIETY—which in union with the Natural History Society of Oxfordshire, celebrated a centenary in 1928.

On the completion of the New Museum in 1860, the zoological collections were taken to the Parks. Certain ethnographical specimens followed in 1886. The Ashmolean Libraries were absorbed by the Bodleian, and lastly the archaeological collections were moved to the University Galleries about 1894.

By the gift of his fine collection of ancient Scientific Instruments Dr. Lewis Evans, and his accompanying condition has once more revived the original association of the Ashmolean Building with the study of the Natural Sciences, and those who visit it may like to be reminded that we have here a unique possession, scientific collections of the seventeenth century and older, in a museum of the same early date.

The public entrance to the Lewis Evans Collection of historical Scientific Instruments is by a new side-door, leading from the Theatre yard through the old Anatomy Room to the main staircase. From thence two large doors open into the old School of Natural History, now being used by lexicographers for finishing the last parts of the *New English Dictionary.*

The Lewis Evans Collection was opened by the Earl of Crawford and Balcarres on May 5, 1925, after the conferment of the honorary degree of Doctor of Science upon Mr. Lewis Evans.

The 'Great Stairs'

The **staircase** is dignified. Broad oaken steps, ascending in easy flights to square roomy landings, give an air of spaciousness, so characteristic of the best buildings of the seventeenth century; and the general effect owes much to the special feature of the turned balusters, a double swelling of the shafts, which, catching the light, greatly contributes to the success of the whole design.

The **Armorial Windows** commemorate benefactors of the seventeenth and twentieth centuries. They were unveiled by Lord Cave, as Chancellor of the University, in 1927 and by Lord Birkenhead, High Sheriff, in 1929.

The **Ashmole** Window presented by the Principal and Fellows of Brasenose College.

Eliae Ashmole huius Musei fundatori Coll: Aen: Nas: Principalis et Socii alumno suo hanc fenestram dedicaverunt MCMXXV

☿

The remarkable treatment of the coat of arms, Ashmole quartering Bowyer, Knypersley, Venables and Grosvenor, has been taken from the design adopted by Ashmole himself for marking certain books, which he deposited in this building. The crest and supporters, Mercury and Gemini, have reference to his twofold interest in chemistry and astrology. He founded the first Professorship of Chemistry in Oxford, and adopted the name '*Mercuriophilus*' as a favourite *nom de plume*. His sign ☿ and the spiders, which drove away his ague, have not been forgotten.

The **Tradescant** Window given by the Garden Clubs of Virginia, U.S.A.

Quos arbusta iuvant celebrant hunc Virginienses Auspice quo nostris sua frons innascitur hortis.

John Tradescant's coat of arms have been copied from an engraving in the *Musaeum Tradescantianum* 1656. They are surrounded by a wreath of the Virginian Spider-wort (*Tradescantia virginica*) which the younger Tradescant was the first to bring to Europe.

The **Wren** Window given by the Royal Institute of British Architects.

Christopherum Wren Astronomiae Professorem Savilianum caelestibus exstructionibus nobilem commemoravit Regalis Societas Architectorum Britannicorum.
MCMXXVII.

It is probable that Wren contributed a design for the Old Ashmolean building without payment.

The **Plot** Window given by University, Magdalen and Hertford Colleges.

Huic celebrant cuius collegia nomen et artem Tradita Musei primo est custodia primi.

In the wreath are the Oxfordshire flowers *Geranium dissectum* and *Viola palustris* described by him as new to the British flora.

The **Evans** Window given by the Friends of the Old Ashmolean.

Ludovicus Evans D.Sc. qui Museum Ashmoleanum denuo locupletavit instrumentis naturalis scientiae collatis hic commemoratur MCMXXV.

The **City Companies** Window given by Sir Dugald Clerk as a record of four of the great Companies of the City of London who by their timely gifts of money made it possible for the University to accept the collection of Dr. Evans on the terms of his offer, viz. that it should be housed in the Old Ashmolean.

Musei armaria instruxit et arcam ditavit gildarum Londiniensium liberalitas quarum insignia depigenda curavit Dugaldus Clerk MCMXXIX.

The Companies whose arms are represented are those of the Goldsmiths, Ironmongers, Clothworkers, and Fishmongers.

The designs have been worked out by Messrs. James Powell of the Whitefriars Glass Works, and the inscriptions are by Mr. J. U. Powell of St. John's College.

Pictures

Against the walls of the staircase are :

A **List of Benefactors of the Ashmolean Museum** from the foundation to 1824: prepared by J. S. Duncan, Keeper, for exhibition in this building.

Engravings illustrating the past history of the **Old Ashmolean Building and its site.** The oldest plan of Oxford, in 1578, and therefore before the Schools Quadrangle or the Bodleian Library was built, shows that at that time there were no houses close outside the City Wall. A later plan by Hollar shows a row of houses there, evidently recently built by squatters along the

line of the City Ditch. Before the Sheldonian Theatre and the Old Ashmolean could be built, certain of these tenements had to be acquired by the University, and the ground cleared.

Engravings from Williams's *Oxonia Depicta.* Colour-prints by J. Farington, R.A., 1793; T. Rowlandson, 1810; Ackerman, 1814. Engravings by Michael Burghers, 1685; Henry Rushbury, 1925. Photograph by J. R. Weaver, Fellow of Trinity.

Portrait of Dr. Plot, first Keeper of the Ashmolean Museum, appointed by Ashmole in 1683. As first Ashmolean Professor of Chemistry he lectured in the middle room of this building from 1683 to 1690, when he left Oxford. He was the author of the *Natural History of Oxfordshire,* and *of Staffordshire,* and Secretary of the Royal Society.

Portraits of the brothers **John Shute Duncan** and **Philip Duncan** under whose Keepership of the Museum from 1823 to 1829 and from 1829 to 1854, there was a revival of these special studies in Natural History for which Ashmole founded his Museum. P. Duncan published a *Catalogue* in 1836.

Painting of **Dr. James Paxton** (1786–1860) lecturing to medical students, *c.* 1840 (*D.N.B*). Pres. by Rev. H. W. Fox to Radcliffe Infirmary and by them to the University.

Silhouette of **Prof. Buckland** signed by Edouard, 1828.

A **Geological Lecture** in the Old Ashmolean.

List of Fellows of the Royal Society, 1663. A photographic facsimile of a broadside belonging to Mr. J. Fulton. No other copy is known.

Ship's Compass invented by Lord Kelvin. From the Admiralty.

The Gallery

From one of the windows of this Gallery, James Bradley may have made astronomical observations when, as Reader in Natural Philosophy, he worked in the Ashmolean. His meridian mark was upon the roof of All Saints Church, now invisible owing to the erection of the Library of Exeter College.

Engraving of **James Bradley**. For his telescope see p. 115.

A selection from the **Medical and Surgical Collections** is shown here.

The Chemical Laboratory

In the **Basement** under a stone vault was the old **Chemical Laboratory**, first in Britain to which the public were admitted either to make experiments or to purchase chemical preparations from the operator. Adjoining was a Chemical Library, some of the books of which have recently been discovered in the Bodleian. Later on, readers of the Oxford Medical School gave practical instruction in these rooms, and even in the eighteenth century, when learning in Oxford was supposed to be at a low ebb, several distinguished persons owed their success in life to their early experiences in the Ashmolean Chemical Laboratory.

Among these should be mentioned James Sadler, the son of a freeman of Oxford who had been trained as assistant to the then University Reader, probably Dr. Kidd or Dr. Bourne, and who in after years turned his scientific knowledge to the good of mankind. In 1784 he made the first of those historic balloon ascents which have earned him the title of 'Father of British Aeronautics', and in the following year he illuminated the Oxford

Town Hall with Coal gas, the first application of this illuminant on a large scale.

Another notability to whom the towns of Malvern and Worcester owe so much was Dr. JOHN WALL, Fellow of Merton College, who analysed the then little-known Malvern waters, and perceiving their therapeutic value, created the new watering-place of Malvern Wells. But he is perhaps better known as the founder of the Porcelain industry at Worcester. About 1740–50 he was doubtless turning to advantage the lessons that he could have learnt from the furnaces in the Old Ashmolean Laboratory, and was experimenting with china clay obtained from Cornwall—concerning which he may have again received information from Dr. William Borlase of Exeter College, or from Thomas Pennant of Queen's whom Borlase had exhorted to make a special study of the minerals of that county. Both Borlase and Pennant were benefactors of the Old Ashmolean, and Wall's son Martin became Public Reader there in 1781. To this day the best recommendation of Old Worcester china is that it shows 'Dr. Wall's blue', and is signed with his mark 'W'.

Among Wall's chemical pupils would have been WILLIAM HIGGINS, who came up to Oxford in 1785. His contemporaries were Gilbert Davies, who succeeded Humphrey Davy as President of the Royal Society ; Edwards, afterwards Lecturer on Chemistry at St. Bartholomew's Hospital; and Smithson, after whom the most famous Institution in America is named. Higgins acted as operator to Beddoes in the Ashmolean Laboratory in 1787, and on leaving Oxford became chemist to the Apothecaries' Hall of Ireland. His claim to fame is that he was the first to write against the phlogiston theory and that he discovered the great law

of Chemical Combination known as the *Law of Multiple Proportions*—usually attributed to Dalton.

The Public Lecture Room *or* School of Natural History

The **Middle Room** is one of the finest in Oxford. Ashmole's Professor of Chemistry used to lecture thrice a week, and when not required for such public occasions, the room was available for the gatherings of the Oxford Philosophical Society. which like the Dublin Society exchanged copies of its proceedings with the Royal Society in London.

In the Keepership of P. Duncan it was adapted as an exhibition gallery, and by the time of the break-up of their Museum, when Philips was Keeper, it had become filled with museum show-cases. After the move of the remaining Antiquities to Beaumont Street in 1894, the editorial staff of the *New English Dictionary* were accommodated with temporary quarters there by leave of the Vice-Chancellor, Dr. T. Fowler.

The Musaeum Ashmoleanum

On the **Upper Storey** are the Great Room of the *Musaeum Ashmoleanum,* now devoted to the Lewis Evans Collection and the Oxford Collections of scientific exhibits, a small Study for the Keeper, and the Library.

The Great Room has been a public Museum for 250 years, excepting for a break of some twenty years when it was used by the newly-founded School of Geography. It is, therefore, our oldest Museum, and its association with Natural Science is unique.

This room was specially chosen by Mr. Lewis Evans as the only available room in Oxford which

he considered suitable for his Collection, so that had the University not then been able to grant its use, his great collection would have gone elsewhere. For some years it was divided into East and West rooms by a partition put in by the Geographers. The Lewis Evans Collection has had this removed and has so effected the restoration of a very fine room to its original proportions; has recovered the original doors from a scrap-heap and has replaced them with their seventeenth-century iron-work.

The Old Ashmolean Library

The Foundation Libraries, given to the Old Ashmolean by Ashmole and his friends Martin Lister, John Aubrey, and Anthony Wood contained very many important works upon Natural History, and are essential to students of the history of Science. They have been removed to the Bodleian in spite of the terms in Ashmole's Will under which they were accepted by the University.

'I bequeath to the Chancellor, Master and Scholars of the University of Oxford all my manuscript books and other manuscript papers not yet sorted, nor bound up, books of copper cuts, and books lynned in colours and all my printed books in the two uppermost turrets at my house in South Lambeth to be preserved in the Musaeum Ashmoleanum in presses, with locks and keys to be provided for them.' Ashmole's *Will*, dated 6 September 1686, proved 1692.

With Ashmole's own library were included the important Libraries of John Booker, and William Lilly, purchased by Ashmole for £140 and £50 respectively, and a selection of the books of John Staniesby of Clements Inn. So that, taken all round, it was for many purposes the most important

collection of books dealing with the history of Science of its day. But they were removed to the Bodleian Library with the others on heraldry, 'news-books, poems, and books of controversy relating to religion' about 1894, and duplicate there many works on those overcrowded shelves.

Dr. Lewis Evans has re-endowed the Old Ashmolean with a second Library of rare books of great importance to students of another part of the history of Science. The Evans Collection is especially rich in books on the history of mathematical and scientific instruments, and more particularly on the history of dialling. Many of these books contain descriptions of instruments now in the Collection, and it would be a calamity if they should ever be alienated from them.

The discovery in the Bodleian of an imperfect, soiled and annotated copy of Serlio's *Des Antiquités*, 1550, from the Old Ashmolean Library, shows clearly that the details of the great East portal were imitated from the Pantheon in Rome, and in all probability from illustrations in this very copy of Serlio's treatise.

The room has recently been partly restored by the removal of partitions, and at the same time its interesting inscription was discovered under a coat of whitewash.

LIBRI IMPRESSI ET MANVSCRIPTI E DONIS CLARISS: VIRORVM D. ELIAE ASHMOLE ET MARTINI LISTER QVIBVS NON PAVCOS ADDIDIT VIR INDVSTRIVS NEC ⟨INFIME⟩ DE RE ANTI⟨QVARIA PROMERITVS D. JOANNES AVBREY DE EASTON PEIRCE APVD WILTONIENSES ARM. ET SOC. REG. SOCIVS

THE HISTORIC COLLECTIONS OF NATURAL HISTORY AND OF SCIENTIFIC APPARATUS

I. THE TRADESCANT MUSEUM OF NATURAL HISTORY, 1634–62

From 1634 to 1662 the Museum and Garden of the Tradescants in Lambeth had been one of the sights of London. The King and Queen, and many other persons of distinction, travellers and sea-captains had all combined to enrich with exotic gifts the exhibition of specimens collected by the Tradescants themselves. Thus came into being the first English scientific collection of natural history specimens of great educational value, for showing not only what distant regions of the globe were producing, but also the uses to which the natural productions from lands overseas could be put, whether for food, clothing, ornament or any other purpose in the service of mankind.

In 1656 Ashmole assisted in the work of cataloguing the Museum, and in 1662 inherited it on the death of the younger Tradescant.

There can be no doubt but that when he offered this collection to Oxford, Ashmole was moved by ideas that anticipated some of those of the founders of our Imperial Institute in modern times.

The 'rich and noble collection of curiosities' was arranged in the *Musæum Ashmoleanum*, having been first 'put into a just series and order by the great care and diligence of the learned Robert Plot'.

In the course of years the collections suffered from the neglect and ignorance of its Keepers, as in 1755 when the unique specimen of the Dodo was ordered to be burnt; still, fairly representative series of certain groups of specimens were in existence in 1836, when a catalogue was published by P. Duncan. In 1860 the entire zoological collection was moved to the new Museum in the Parks and was distributed among the teaching collections of the Professor of Comparative Anatomy. By the kindness of Professor Goodrich a group of the smaller Tradescant specimens has been prepared. For modern teaching their value is perhaps not as great as that of modern specimens: but as a memento of the oldest public Museum of Natural History in Britain, their exhibition in the Old Ashmolean in the very room that was specially built and fitted for their reception in 1683 is unique and historic.

It is sincerely to be hoped that the scattered remainder may once more be brought together and carefully guarded against further losses.

Of popular interest are the specimens of South American Globe Fish; Armadillo; Elk's foot with a third hoof; Elephant's tail with unusually long hair; Warthog's skull; Crocodile, part of skin, presumably from lower reaches of Nile where it is now extinct; Saw-fish, saws; picture of Dodo.[1]

Tradescant dealt 'with all merchants from all places, but especially from Virginia, Bermudas, Newfoundland, Guinea, Binny, the Amazon, and the East Indies, for all manner of rare Beasts, Fowls and Birds, Shells, Furs, and Stones'.

[1] Photographs of the entire collection have been printed in *Early Science in Oxford*, vol. iii.

II. THE ASHMOLEAN GEOLOGICAL COLLECTIONS, 1690–9

These collections date from a period when the differences between *formed stones* and petrified organic remains were just beginning to be recognized.

Robert Plot bestowed at his resignation of the place of Keeper a very large collection of Natural Bodies, being such as he had figured and described in his *Histories of Oxfordshire* and *Staffordshire*; which the University, 'according to their usual constant care for the preservation and furtherance of all useful knowledge, have reposited in two large Cabinets, distinguished in the catalogue of the Museum by the names *Scrinium Plotianum Oxoniense* and *Scrinium Plotianum Staffordiense*.

All Plot's type-specimens have been *lost*. And until last year it was believed that the larger and even more important collection of his successor Edward Lhwyd, had almost entirely suffered the same fate. A small oaken cabinet, believed to have belonged to Richard Dyer, Fellow of Oriel, and for many years in the Library of that College has, however, been found to contain a number of fossils enclosed in their original paper wrappings, inscribed with name, locality, and serial number, all of which have been discovered to agree with the descriptions written by Edward Lhwyd, the second Keeper of the Museum (1690–1708), and published by him in 1699 in his pioneer work on British Palaeontology, the *Lithophylacii Britannici Ichnographia*.

These fossils that have been discovered in Oriel are therefore of the highest historic interest, not only because they were a part of the oldest Geological Collection in Oxford, but because they are

the original type-specimens described, and in some cases figured, by Lhwyd in his classical work. But how they came to be removed from the Old Ashmolean Museum will probably always remain a mystery.

Attention has already been drawn to the type-specimen of *Ornithella digona* from Witney which Lhwyd was the first to describe and figure, under the name of *Sacculus minor vulgaris* (No. 873, Tab. 10), by Dr. Arkell of New College, in his paper on *The Upper Great Oolite.* The Echinoderms have been worked out by Professor Herbert L. Hawkins of the University of Reading, who has identified eleven specimens.

In addition there are a number of nuts, seeds, and other exotic vegetable products, and also a small collection of shells of Mollusca. Some of the seeds have most certainly come from Barbados and may have been collected at the same time as those in the Pointer Collection (cf. *Early Science in Oxford,* iii, p. 520) which were obtained by Richard Dyer, who gave coins to the Ashmolean in 1700.

III. THE ORRERY COLLECTION, *c.* 1700

By the generosity of the Governing Body of Christ Church the Orrery Collection is on view in juxtaposition to the Lewis Evans Collection, an association which cannot but greatly facilitate the ultimate working out of both collections.

The greater part of the collection has the special interest of having been made by one man, who was great-nephew to the Hon. Robert Boyle. The oldest piece is dated 1658, and the greater number of instruments appear to have been acquired between 1690 and 1710. It may well be that in the Orrery Collection, Oxford has the largest, if

not the only considerable collection of scientific apparatus, now in existence, formed by any one person who lived so long ago.

Charles Boyle, fourth Earl Orrery, like a recent Duke of Marlborough, was a wealthy scientific amateur, a patron of good work rather than an original investigator. The interest attaching to his collection is therefore not the interest that would now attach to the apparatus of a Robert Boyle, or of a Newton, or of a Galileo; but at the time it was probably considered far more valuable than the rough-and-ready contrivances with which great discoveries are frequently made.

Its modern interest lies in its preservation of the best work of which the most skilful scientific craftsmen of the time were capable. Several of the instruments are likewise among the earliest of their kind now extant.

Lord Orrery died in August 1731.

The following items are of especial interest:—

Two telescopes with eight- or nine-draw vellum tubes, which are wider towards the eyepiece end.

An early Gregorian Reflecting Telescope. A Refracting Telescope with object glass signed *J. Wilson.* A very early Eyepiece Micrometer.

The earliest English Compound Microscopes of *Wilson* [1702], and *Marshall* [1704].

The auxiliary appliances for both instruments seem to be absolutely complete; the latter may be a unique possession.

Four fine Planetaria by *John Rowley* illustrating the differences between the Ptolemaic and Copernican Theories of the Solar System.

An exquisitely finished silver model of the Copernican Sphere in a casket, by the same maker.

An original Plane-table by *Worgan,* dated 1696,

with its 22-inch alidade, probably the oldest now extant; a Circumferentor by the same maker; and a Graphometer on tripod.

Bubble and Spirit Levels.

Various highly finished mathematical instruments by *Rowley* and *Sisson*—the best English instrument-makers of their time.

Lord Orrery's Collection is appropriately flanked by two beautiful specimens of the instrument to to which his name has been given.

IV. THE POINTER MUSEUM, *c.* 1720

'The Pointerian Museum' owes its importance to the fact that it is the only known teaching collection of an Oxford Tutor during the early years of the eighteenth century. That it should have been preserved in its entirety, though damaged, in and under the library of St. John's College, is little short of miraculous. The original catalogue and notes of lectures on the specimens are still extant, together with a copy of the remarkable advertisement put out by the lecturer in 1731.

Advertisement. *May* 24. 1731.

IF any Gentlemen (that design to study Physick, or have otherwise a mind to divert themselves with the study of Natural Philosophy) are willing to go thro' a Course of *Pharmacy*, *Botany*, *Minerology*, and *Metallology*, and have a mind to be acquainted with the several Sorts of Metals, Minerals, Medicinal Salts, Bitumens, Earths, and Ores, as also the several Sorts of Gums, Juices, Chymical Preparations, Exotick Fruits, Plants, Roots, Seeds, Barks, and Flowers; Mr. *Pointer* of *Merton* College, who has got a compleat Collection of the Physical Drugs that are now in Use, will be ready to attend them at his Chamber in *Merton* College, to shew 'em Specimens of each Drug, and also to read Lectures upon the same (which he has prepar'd and collected from the best Physical Authors extant) explaining the Virtues and Uses of

them, all in order according to their proper Classes, every Day till they have gone thro' the whole Course.

The Course will begin on the 21st of *June* next, at Two o' Clock in the afternoon. Each Gentleman to pay a Guinea at entrance, and that's all. They are to enter their Names beforehand at Mr. *Lasher*'s the Apothecary.

And when this Course is ended, they may (if they please) be entertain'd Gratis with the Sight and Explanation of a Collection of 500 Greek and Roman, as well as Modern Coins and Medals of all Sorts, as also a Collection of Antiquities and Curiosities both Natural and Artificial.

The reward promised in the last paragraph is a priceless testimony of the position of Natural Science in the Oxford of 1731.

The smaller natural history specimens are contained in eleven drawers, each divided into ninety compartments.

Earths	Woods	Animals
Minerals	Barks	Shells
Petrifactions	Nuts, Seeds	Birds' Eggs
Fossils	Gums	

V. THE CLUTTON COLLECTION OF MATERIA MEDICA, 1729

This Collection was made by Joseph Clutton, an apothecary of Holborn, apparently to the order of Thomas Jobber. Later it came into the possession of Oglander, Warden of New College, on whose death it was put into the muniment room of the College, where it remained until 1925. It is the oldest collection of Materia Medica in its original state in this country, and of first-rate importance for the identification of many medicinal simples. There are other old specimens in well-known collections such as that of the Pharmaceutical Society and in Edinburgh, but as they also comprise so many

placements of modern date they have not the same historic value as this New College Collection.

The original bill is preserved:

Tho. Jobber Esqr Bought of Jos Clutton Holbourn London

2 Mo^{t} 20 1729	A Mehogony Cabinett & frame the Workmans Bill is —	5 : 7 : 9
	Paper to line ye same —	0 : 2 : 2
	Flint Glasses cut with brass Caps (28) n.	0 : 10 : 8
	Two large Volums/to hold 460 sp^{ns}	
460	of Plants/cost — — — — —	0 : 10 : 4
	The Specimens themselves — —	3 : 3 : 0
12	Specimens of Animals — — —	0 : 6 : 0
50	of Parts of An^{ls} — — — —	1 : 5 : 0
29	of all y^{e} Metalls oars. Recrem^{ts} &c	1 : 5 : 0
28	of Pretious stones each about ℥ij	1 : 5 : 2
51	of Minerales Marine: Sulphureous &c each ℥i	
109	of Roots each about ℥i	0 : 12 : 9
		1 : 16 : 4
17	of Woods ℥i — — — — —	0 : 8 : 6
19	of Barks ℥i — — — — —	0 : 6 : 4
53	of Gums, Resins, Balsams @ ℥ ss	1 : 9 : 5
17	of Juices &c — ℥i — — —	0 : 4 : 3
33	of Flowers — ℥ ss — — —	0 : 5 : 6
154	of Fruits, Seeds &c ℥ ss — —	1 : 8 : 6
	setting these 1032 Spec^{ns} in order w^{h} curiously pickd & chosen, and lining y^{e} cells with coffins, labelling &c was about 60 days work, left to himself w^{h} he pleases.	21 : 06 : 08

The Collection is arranged in small compartments in six drawers, as follows :—

I. Flores (32); Fructus, Semina, Nuces (156).

II. Radices (96).

III. Ligna (16); Cortices (18); Gummi, Resinae, Balsama (56); Succi (18).

IV. Metalla Recrementa (28); Lapides Pretiosi (24); Mineralia (15); Sulphuria (28).

V. Partes Animalium (31) and Hortus siccus, Vol. 1.

VI. Animalium Partes (23) and Hortus siccus, Vol. 2.

VI. THE THOMPSON COLLECTION, *c.* 1750

The Instruments that belonged to a family of practical land-surveyors in the midlands. See p. 82.

VII. THE ORIEL COLLECTION OF PHILOSOPHICAL APPARATUS, *c.* 1790

Just as the Orrery Collection belonging to Christ Church illustrates the nature of the best scientific apparatus available for instruction or research at the end of the seventeenth and the beginning of the eighteenth centuries, so the Oriel Collection includes a selection of the instruments that were considered needful at the end of the **eighteenth century.** In many respects the outlook of the physicist had changed in that period of 100 years. The Microscope had taken on a more modern form; Mechanics and Pneumatics were being taught with appropriate and standardized apparatus; Hadley's Sextant had ousted the astrolabes and quadrants of an earlier day; and the entirely new science of Statical Electricity was exciting the wonder of the experimenters. Regularized experimental lectures by Desaguliers and others had doubtless helped to bring about this revolution in the methods of the teaching of Physics. It is supposed that, like a model of a **Pile Driver,** they were part of Lord Leigh's benefaction. The instruments were made for the most

part by Edward Nairne (1761–1806). But we miss the Artistic design of the instruments of the earlier century.

Both the Orrery and the Oriel Collections recall Priestley's advice to Lord Shelburne.

'My view in advising your Lordship to establish a laboratory for philosophic purposes was double. First, to accustom Lord Fitzmaurice, at an early age, to the use of philosophic instruments, and the sight of philosophic experiments and processes, in order to do for him, if he should happen to acquire a taste for natural science, what all his fortune will not otherwise be able to do—namely, to make him happy in active and pleasing pursuits at home.'

Lord Shelburne paid £155 for such a Collection of 'philosophical instruments'.

VIII. THE ASHMOLEAN COLLECTION OF CHEMICAL AND PHYSICAL APPARATUS[1]

The Daubeny Collections at Magdalen include many pieces used in the Old Ashmolean between 1790 and 1822, when Daubeny became Aldrichian Professor of Chemistry. He appears to have transferred the entire equipment in 1847 to his new laboratory at Magdalen College, where the unique Collection has suffered loss by attrition, and from need of good curating. It is a pity that original historic apparatus of Faraday, Davy, Tyndall and others should be in danger of being lost. Once gone it can never be recovered.

The work of Charles Daubeny in Oxford is not less remarkable. His pioneer teaching led the way to our modern Science School. Those who attended his courses of experimental Science achieved the highest distinction in Church and

[1] Figured and described in *Early Science in Oxford*, vol. i, wherein a list of Ashmolean apparatus is on p. 77.

State. He was one of the Fathers of the British Association. His research on the *Action of Light upon Plants and of Plants upon the Atmosphere* is one of the classics of British Science. His advocacy of the use of phosphates for manure did much to revolutionize agricultural practice. Much of what is left of his scientific apparatus is well worthy of conservation. There is so little that is left of its period in the Museums of the world.

Some of the salt-glaze Retorts bear the make of WEDGWOOD of the period 1805–15. The glass-ware was obtained from *F. Accum*, of Soho: a bill-head from one of whose accounts, presented by Mr. J. Johnson, is exhibited with the apparatus.

IX. ROYAL ASTRONOMICAL SOCIETY'S COLLECTION, *c.* 1800–70

The Royal Astronomical Society's collection of Astronomical, Optical, Magnetical, and Mathematical Instruments were specially selected from the larger loan collection of 148 items. A brief description of the chief of these instruments and other particulars relating to them was printed in the *Monthly Notices*, vol. xxxvi, p. 126, and to this list the numbers given in brackets refer.

Having been designed and constructed by the leading makers of instruments of precision, they illustrate that period in the history of astronomical measuring which immediately followed a period well illustrated in Oxford by *Bird's* great quadrants and sector at the Radcliffe Observatory, and preceded the period of Professor Pritchard's University Observatory in the Parks, when photographic methods began to take the place of earlier methods for the accurate determination of stellar positions.

Several of the instruments formed part of the collection of the Rev. Richard Sheepshanks of Trinity College, Cambridge, and after his death were presented to the R.A.S. by his sister Miss Sheepshanks of London Street, Reading, in June 1857. For a number of years these instruments were available for lending to Fellows of the Society. The show-case has been made out of an old shop front demolished to make way for the new Morris Garage in St. Aldate's.

The instruments are listed on pages 118–123.

X. THE CONRAD COOKE COLLECTION

Conrad W. Cooke, member of the Institute of Electrical Engineers whose collection of Scientific objects was dispersed by auction on 16 December, 1926. The Evans Collection was fortunate to have been able to secure a few of his specimens ; notably some of Sir William Crooke's early vacuum tubes, Priestley's Thunder house, Wollaston's portable Equatorial, and other important exhibits.

To Mrs. Cooke we owe a corrected copy of his *Automata Old and New,* 1893, and the MS. of his *Hero of Alexandria,* 1901.

XI. THE CRISP AND NELSON COLLECTIONS

Sir Frank Crisp, Bart., of Friars Park, Henley-on-Thames, was alike distinguished as a horticulturist and a microscopist who with the assistance of Mr. J. Mayall, junr., about 1880–90 made the largest and most important collection of Microscopes that had ever been got together. In its entirety it consisted of nearly 3,000 Microscopes and over 1,000 pieces of apparatus, many of which were historic and unique. Sir Frank had once

invited the writer to catalogue his collection, but this was unfortunately impossible at the time, and unfortunate, because, had we been able to assist him then, this great collection would probably have come to Oxford in its entirety. As it was, it was sold by auction in the years 1920–5 and much of the history of the instruments has been lost.

The Collection was of especial importance from the point of view of the evolution of stands. The greater part of the Collection was purchased by the cataloguer, Mr. Court, and parts are in the Science and Welcome Museums in London.

The Edward Milnes Nelson gift includes a few Microscopes of great historic importance together with an invaluable series of object-glasses, the construction of which he understood as few others have done, and did much to improve. Few people of his generation have done more to improve microscopes and the technique of their use than Mr. Nelson.

XII. THE LEWIS EVANS COLLECTION

Dr. Lewis Evans, the refounder of the Old Ashmolean Museum, was born on 15 February, 1853, and obtained the greater number of mathematical instruments and portable sundials of which his collection principally consisted between 1890 and 1910. He offered them to Oxford in 1922, but on the condition that it should be kept in the upper room of the Old Ashmolean. He was averse to its being treated as an Art Collection and desired that it should be publicly exhibited with scientific objects as a record of what scientific instrument-makers could accomplish in the past. Our Guide to the Collections will begin with his contribution.

THE
LEWIS EVANS COLLECTION

The North Desk Cases, **1–8.**

ASTROLABES

The **Astrolabe Collection,** comprising some sixty-three examples, taken in conjunction with those already in Oxford and the MSS. in the Bodleian, forms the largest and most representative series in the world of this rare and beautiful instrument.

It has all the glamour of an ancient descent. Its sight-rule, or *Alidade,* which is used for taking observations, has certainly been derived from the Greek diopter, which is here placed diametrically across the centre of a vertical circle, divided into degrees. To this instrument, by which altitudes of sun and stars are measured, has been added a simple form of adjustable planisphere, or flat map of the stars, known as the *rete,* which can be set so as to show the time corresponding to the arrival of the chosen luminary at the observed altitude on any day in the year.

The astrolabe was saved from the wreckage of Greek civilization by the Arabs, and by them introduced into Spain. In the time of Roger Bacon, when Oxford scholars first travelled in southern climes, it may have been one of those

costly astronomical instruments which were 'not to be found among the Latins, nor could they be made for two or three hundred pounds'. Bacon may have used them in Toledo, and have lamented the lack of them in Oxford. In the fourteenth century his successors of the Merton School partly remedied the deficiency by the acquisition of simple instruments, one of which, *c.* 1340, is exhibited by Oriel College. The astrolabe was the first scientific instrument to be described at length in the English language, and we owe the treatise to the desire of our great astronomer-poet CHAUCER that his son might learn rightly to 'knowe every tyme of the day by light of the sonne, and every tyme of the night by the fixed sterres', to know the beginning and end of dawn and of evening twilight, to find the meridian altitude of the sun, to know the latitude of any place, to find the points of the compass, and to measure heights and distances of inaccessible objects—in short it was a 'mathematical jewel', a key to much of the Wisdom of the East.

Chaucer had no dreams of the great work that the future would lay upon his instrument. His chief concern was that there was no simple account of it in plain English. He had sent 'litell Lowis' up to Oxford at the tender age of ten under the tutorship of the 'nobilissimi philosophi Magistri', N. Strode. The childish fancy of Lowis had evidently been struck by the mystery and attractive appearance of an astrolabe, and he had asked his father if he might learn about it. The father being pleased with the child's 'abilite to lerne sciencez touchinge noumbres and proporciouns', i.e. arithmetic, sent him a small astrolabe, 'a smal instrument portatif aboute' by way of combining instruction with reward. The instrument

was what the Arabians termed a *misfi*, being engraved with 45 circles of latitude for alternate degrees, instead of with the whole 90 that find room on the largest and best instruments; or, in Chaucerian language, 'the almikanteras in thyn Astrolabie been compouned by two and two'. This, however, was a 'suffisaunt' astrolabe for the purpose. The father, moreover, believed the Latin treatises to be too hard for his son's use and the conclusions in them not to be always reliable. He therefore proposed to select some of the more important conclusions, and to turn them into English with such amplifications as would render them easier for a child to understand. Chaucer makes no pretence to originality. 'I am but a compilatour of the labour of olde Astrologiens, and have it translated in myn English only for thy doctrine; and with this swerd shal I sleen envye.' The result was a treatise which after five hundred years is still the standard work on the subject in our language.

The astrolabes are grouped according to countries:

THE PERSIAN SERIES **1 & 2**

Persian Astrolabe of Ahmad and Mahmūd, A.H. 374 = A.D. 984. This is the earliest dated scientific instrument known. It is dedicated in Persian: 'IN THE NAME OF GOD, AND BY THE HELP OF GOD, IN PROSPERITY, AND WEALTH AND GOOD FORTUNE, AND THE HAPPINESS OF THIS WORLD AND THE NEXT AND ETERNITY. THIS IS THE ASTROLABE OF AHMAD AND MAHMŪD, THE SONS OF IBRAHIM, THE ASTROLABIST OF ISFAHAN.'

Persian Astrolabe, A.D. 1227. A superb instrument enriched with gold and silver, made

for Abool-Fetih Moosa, son of Aboo-Bekr. Inscribed :

'THIS IS MADE BY ORDER OF OUR MASTER KING AND SOVEREIGN : THE MOST NOBLE, AND THE GREAT PRINCE, THE GLORIOUS AND THE MAGNANIMOUS ; THE LEARNED AND THE JUST. THE WARRIOR AND THE CONSTANT, THE STRONG AND THE VICTORIOUS, THE CONQUEROR OF THE WORLD OF NATIONS. THE EXTOLLER OF THE TRUE FAITH. THE KING OF MUSSALMANS, THE HELPER OF PRINCES, THE AUXILIARY OF MANKIND, THE TREASURE OF THE EMPIRE. THE ACCOMPLISHMENT OF THE PEOPLE ; THE GLORY OF THE RELIGION ; MASTER OF KINGS AND MONARCHS ; THE SHELTER OF THE TROOPS OF THE STATE, THE DESTROYER OF THE INFIDELS AND IDOLATERS ; THE SUBDUER OF THE SCHISMATICKS AND THE REBELS ; THE EXTIRPATOR OF THE ATHEISTS ; THE CONSUMER OF THE PERTINACY ; THE DISSIPATOR OF THE INJURIOUS AND THE INSOLENT PEOPLE, THE EXPELLER OF SEDITIONS FROM TOWNS ; THE HERO OF THE WORLD ; THE KHOSROE OF IRAK THE PROTECTOR OF THE UNIVERSE ; THE GUARDER OF THE DEFILES ; THE ADJUTOR OF THE PEOPLE ; THE KING OF ARABIA, PERSIA AND ARMENIA ; AND THE VICTORIOUS COMMANDER OF THE TRUE BELIEVERS. *ABOOL-FETIH MOOSA*, SON OF THE VICTORIOUS KING ABOO-BEKR, SON OF AYUB.

MAY THE GOD ALMIGHTY RENDER HIM VICTORIOUS.'

Persian Astrolabe, dated A.D. 1647, weighing 18 lb. 4 oz.

Made by 'Muhammad Shafi, the astronomer of Janabad and the skill of Yazd', for Shah Abbas II. Inscribed :

BY THE ORDER OF HIS MOST EXCELLENT MAJESTY THE SULTAN. THE JUST, THE GREAT, LORD OF THE CENTRES OF COMMAND, REMOVER OF THE CAUSES OF TYRANNY AND REBELLION, KING OF THE KINGS OF THE

AGE, *ABU MUZAFFAR SULTAN SHAH ABBAS II*, THE SAFAWI, THE MUSAWI, THE HUSAINI, BAHADUR KHAN.

MAY GOD ALMIGHTY PERPETUATE HIS KINGDOM AND HIS EMPIRE AND CAUSE TO SPREAD OVER THE WORLDS HIS JUSTICE AND HIS BENEFITS WHILE THE SPHERES REVOLVE AND THE PLANETS CONTINUE THEIR COURSES.

The Indian Series **Case 3**

The **Indian Series** begins with a fine Astrolabe, A.D. 1634, MADE BY THE LEAST SERVANT OF GOD MOHAMMAD IBN ESA IBN EL HADDADA, ASTERLABI LAHORI HAMAYUNI, according to a further inscription in 'the eighth year from the coronation of Shah Jehan'.

The 'Kursi' or throne is enriched with beautiful open work, irregularly pierced in 37 places. Like several other Indian astrolabes the quadrant on the back is crossed by a curved line, 'The line of altitude at middle day', which shows the altitude of the sun, when in the different signs, for the latitude of Lahore 32°.

Indian Astrolabe, A.D. 1644, THE WORK OF THE HUMBLE SERVANT OF GOD, MOHAMMAD MEKYM (?) IBN TYSE (the Christian) IBN AL HADDAD (the locksmith) ASTERLABI, in the year of Hegira 1053.

The Egyptian Astrolabe

Egyptian Astrolabe, A.D. 1282–3. An unusual type of instrument consisting of a suspension shackle and circular plate, engraved with quadrants and Coptic numerals.

MADE BY AHMAD SON OF ALI IN CAIRO, IN THE YEAR A.H. 681.

The Moorish Series

Several of these astrolabes have the special interest of having been made by Moors in Spain.

They therefore illustrate a most important stage in the introduction of Arabian culture into Spain, whence it spread over Western Europe.

Moorish Astrolabe, A.D. 1067. Made by Ibrahim Ibn Said Assohli in the city of Toledo in the year 460.

In style it is not unlike the astrolabe presented to the Bodleian by Selden. It is noteworthy as an example of a scientific instrument used about the time of the Norman conquest of Britain.

Moorish Astrolabe, A.D. 1221. BISMILLAH. MADE BY MOHAMMAD IBN FOUTOUH AL KHEMAIRI IN THE CITY OF SEVILLE THE YEAR 618 HEGIRA.

Moorish Astrolabe, A.D. 1494. ITS MAKER IS THE HUMBLE SERVANT OF HIS LORD MUHAMMAD THE SON OF AHMAD AL-BATUTI, GOD SUPPORT HIM. YEAR 900 OF THE HEGIRA.

The rete is of later date than the rest of the instrument.

THE SPANISH SERIES **Case 4**

Two examples illustrate the astrolabe after it had been transmuted from the Oriental into European form. The names of the months and of the signs now appear in Latin.

The older instrument, $11\frac{1}{8}$ inches in diameter, may be dated *c.* 1450, and would therefore be of a type with which Columbus may have been familiar. The later example, A.D. 1558, shows an unusually elaborate shackle and swivel. It was made for the longitude of Caesarea Augusta (Zaragoza).

THE ITALIAN SERIES

Italian Astrolabes of dates *c.* 1350, *c.* 1400 *c.* 1460, *c.* 1500.

An **Astrological Astrolabe,** *c.* 1450–1500. The base plate is divided into 12 houses numbered and inscribed 'vita, lucru, feratr, pater, filio, serus, uxor, morse, iter, dominus, amicus, carcere'. Above it are 9 revolving discs marked with names of planets, and a dragon index-arm.

Dantes' Astrolabe, *c.* 1580.

A large instrument, $16\frac{1}{8}$ inches in diameter, inscribed · F · EGNATIVS · DANTES with a coat of arms. The back is engraved with an orthographic projection of the sphere on the plane of the meridian, known as the 'astrolabe of Joannes de Roias'.

THE FRENCH AND FLEMISH SERIES **Cases 5, 6**

French Astrolabe, *c.* 1350–1400.

One of the seven plates is inscribed PARISIUS. Purchased at the Roussel sale, lot 82.

French Astrolabes dated *c.* 1400, *c.* 1600, *c.* 1560, 1595. The last is inscribed ICK TOEBEHOORE PHILIS DE DIN, and on the back, round IHS, is SIT NOMEN DOMINI BENEDICTUM IN SECULA SECULORUM 1595.

An **Astrolabe Case** of leather work, with wrought iron fastenings.

Cuiniet's Geographical Astrolabe, A.D. 1560.

By Aegidius Cuiniet of Antwerp, who may have been the father of Michael Coignet of Paris, 1598.

Flemish Astrolabe, A.D. 1565. Made by Regnerus Arsenius, nephew of Gemma Frisius. A similar instrument by Walter Arsenius belongs to Merton College.

Geographical Astrolabe, *c.* 1580. One plate engraved on one side only with a polar projection

of the world to the tropic of Cancer. ARN SIC VITA PER HORAS. On the back is a perpetual calendar with one revolving disc.

Paper Astrolabe, 1584, PHILIPUS DANFRIEUS, SIDEROGRAPHUS REGIUS GENERALIS LUTETIAE EXARABAT, ANNO SALUTIS 1584, also HOC DORSUM KALĒDARIO REFORMATO PRECISE ACŌMODATUM EST PER J. GOSSELINUM CUSTODEM REGIAE BIBLIOTHECAE REGIS FRANCORUM (*c.* 1580).

THE GERMAN SERIES **Case 7**

♄ △ ♭'s **Astrolabe,** A.D. 1490.

Johan Wagner's Nuremberg Astrolabe, A.D. 1538.

Hartman's Nuremberg Astrolabes, A.D. 1527 and 1535, overprinted 1542.

The older example with other mathematical instruments was given in 1634 to St. John's College by Archbishop Laud, whose arms are engraved upon the back. The bracket is artistically chased with scrolls and two roses, a design which may also be seen upon Dr. Lewis Evans's paper astrolabe marked GEORGIVS HARTMAN NORENBERGE FACIEBAT ANNO MDXXXXII.

Hartman's graduations and finish were finer and more accurate than those of the instruments of his predecessors.

Erasmus Habermel's Astrolabe.

The coat of arms, three rose-trees, shows that this instrument was one of a series made for Franciscus de Padua, a doctor of medicine of Forli.

Lynden's Astrolabes, *c.* 1580.

John Krabbe's Paper Astrolabe, 1583.

Astrolabe Clock. South-German, *c.* 1630. Deposited by Miss Willmott.

This clock with its many dials, elaborate movements, and astrolabe and calendar faces represents in an elaborate, seventeenth-century form what Richard of Wallingford attempted with his cruder Albion in the fourteenth century

THE ENGLISH SERIES **Case 8**

The Oriel Astrolabe and Quadrant, *c.* 1340. Dia. $13\frac{4}{10}$ in.

This instrument and the 1350 Astrolabe in Merton College belong to a very rare type of which, so far as we know, there are no early English examples out of Oxford, and which may have been constructed for some member of the early School of Astronomy at Merton College. The chief peculiarity of the type consists in the absence of changeable tablets and of a raised rim round the base plate to contain tablets and rete. They are astrolabes without a 'mother', and they are combined with quadrants of large size. They resemble the Saphea of William Anglicus, 1231.

A bracket for suspension has been torn away from the notch at the upper side of the thin disc. The rete bears names of 18 stars. On the periphery are inscribed the names of the months, from which it may be seen that the first point of Aries corresponds to $11\frac{1}{2}$ of March. The inner portion of the face is engraved with a table approximately suited for the latitude of Oxford 52°. The almucantars are drawn for every third degree; the astrolabe is therefore a 'thulthi' or tripartite.

Upon the back are the following instruments: (1) A quadrant of $9\frac{6}{10}$ in. radius. The plummet-

line was suspended from a small hanging brass arm or *brachiolus.* (2) A quadrantal scale of *umbra recta* and *umbra versa.* (3) Lines of an *instrumentum horarum inaequalium.*

This astrolabe may have come to Oriel through Simon Bredon, a noted physician, mathematician, and astronomer, and a Fellow of Merton about 1330. He was therefore an original member of that eminent school of astronomers of which Ashendon and Rede were the reputed founders. Bredon wrote on the eclipse of 1345, and at his death in 1372 left by will a large collection of mathematical and astronomical works to Oriel College.

Paper Astrolabes

Observers who could not afford to purchase expensive metal astrolabes appear to have made use of instruments made of wood or cardboard, and paper, usually printed from an engraved plate. There are four such paper astrolabes in the Evans collection; by George Hartman 1542, J. Krabbe, Philip Danfries, 1584, and one by John Prujean. This last instrument is of particular interest to us in Oxford because it was printed and put together by a forgotten local instrument-maker whose place of business in 1667 was in New College Lane, west of Short's Coffee House on the west side of Hell Passage, opposite where Hertford College now stands.

John Prujean's Paper Astrolabe, *c.* 1670.

Made for lat. 51° 45′.

The rete and co-ordinate lines were printed on paper from engraved plates, cut out and pasted on boards.

It is likely to have been one of the last astrolabes to be manufactured in England. Their place

has been taken by the instruments devised by Ferguson and others, which preceded the modern Planisphere, of which the one published by Phillips is a familiar type.

C. F. Jenkins's **Oxford Astrolabe** 1925. The rete is printed on celluloid rotates over a paper plate mounted on a disk of aluminium. The instrument has also been made as a lantern slide by Messrs. W. Watson of 313 High Holborn.

Mariner's Astrolabe

About 1484 the Astrolabe which had been 'before used only in Astronomie' was somewhat simplified and adapted for use on board ship

John II, King of Portugal, was particularly active in securing the best instrumental aid for navigators. He 'sent men of purpose into Arabia and other countries of the East to learne further knowledge thereof'. He also commissioned Martin Behaim to teach pilots to 'navigate by the altitudes of the sun and stars'. Majorcan pilots had, however, navigated with the astrolabe at least as early as 1295. At the time of Columbus seamen used it to observe meridian altitudes of the sun, whence they calculated the latitude. And it continued in use until 1731, when it was superseded by Hadley's Sextant.

Mariner's Astrolabe.

Base plate marked A*, with ring and shackle : restored by the addition of a wooden alidade.

This instrument, once used on every ship, is now represented in England only by one perfect example, which was found at Valencia in 1845. The example lent for exhibition with the Evans collection was brought up from the bottom of the harbour of Vera Cruz by a sand-pump dredger.

It was reported that 'the harbour must have been full of much old treasure, for there were a considerable number of old wrecks'—presumably Spanish.

The first English example by *Elias Allen* dated 1616 at St. Andrews is represented by a full-sized model.

SUNDIALS

Here are provisionally grouped a few of the larger dials, which do not conveniently go with others of their type.

Anglo-Saxon Dial from the Bewcastle Cross. This important example has been considered to be as old as *c.* A.D., 675 for which reasons are given in Baldwin Brown, *Arts of Early England.* The nearest local examples of Saxon Dials are at Daglingworth and Saintbury in Gloucestershire. The Saxons divided the 12 day-hours into four tides of three hours each. The gnomon was usually a wooden peg fixed in the style-hole at right angles to the wall.

Drawings of **Scratch Dials** on churches near Oxford.

German Polyhedral Dial.

Large Stone **Polyhedral Dial** from Burford Priory, presented by Mrs. Emslie J. Horniman.

Hone-stone Horizontal Dials with decorative carving and inscriptions in relief. Two with chronograms.

Window Dials

Against the North windows are two **Glass Dials.** The smaller one, dated 1648, is marked with hour-lines for IV to XI; the larger one has hour-lines for IIII to IX, radiating from a panel

bearing the crest of the owner, a wing charged with 3 crescents on a pale. The mottos are *Vesper in Ambiguo est. Mora noxia cras nil age⟨n⟩dum.* A goldfinch is painted on one side.

These dials recall the only window dial in Oxford. It is in the Convocation House, a beautiful little example of the art of glass painting showing the afternoon hours II to VIII in a yellow border round paintings of a brimstone butterfly, a rose, and some flying insect resembling a gnat.

THE EVANS COLLECTION OF PORTABLE DIALS

The Evans Collection is exceptionally rich in its long series of Portable Dials, representing the work of makers belonging to all the countries of Europe. No other scientific instrument can be illustrated by such series, extending as these do over many centuries. Indeed their compactness, the very essence of their portability, is their merit, for it has resulted in a maximum of fine workmanship being crammed into a minimum space, consistent with a certain degree of accuracy in the time ascertainable by their use. To the same quality of portability many owe their preservation.

The old makers doubtless made larger scientific apparatus as well, but while the larger and more cumbrous instruments have not been kept, these small works of art have been cherished through the centuries, and now in several cases are the only evidence of the master's skill.

The shapes of portable sundials are legion, but as timepieces their theory depends on one of two principles—either upon the *altitude* of the sun above the horizon, or else on its *position* in its daily

course. To obtain the time by a dial it is necessary to know either the declination, or the meridian, but it is not necessary to know both. Both types were doubtless independently evolved from fixed dials. And as the meridian dials are provided with magnetic compasses, portable dials may be conveniently classified either as Non-compass Dials or as Compass Dials.

The exigencies of space and other considerations have prevented any attempt being made at a strictly scientific arrangement of the Dials, indeed in most cases Nationality has been given a prior claim; still, when the full Catalogue is prepared, it should be made to conform more uniformly with some such scheme as the following, which has been sketched out for the purpose by our friend and benefactor Sir John Findlay.

Non-compass Dials

These may be divided into seven classes.

(1) Dials based on a projection of the sphere. The most important group is that of the astrolabes, of which there are three kinds.

a. The ordinary Astrolabe called Stöffler's or Messahala's, based on a stereographic projection on the plane of the equator. This is the ordinary type.

b. The Astrolabe known as that of Joannes de Roias based on an *orthographic* projection on the plane of the meridian. There are at least two examples of this type in the collection, one made by F. Egnatius Dantes and another by Henry Sutton.

c. The Astrolabe of Gemma Frisius based on a *stereographic* projection on the plane of the

meridian. There is an example of this on the back of the large astrolabe made by Regnerus Arsenius.

(2) Dials based on a modification of the orthographic projection, called the *straight lined analemma.* Of this there are three types all of which are represented.

a. The Universal type.

b. The Capuchin or Monk's head type, made for a definite latitude.

c. The Ship dial in its various forms.

(3) Multiple Ring Dials. Of these there are three forms.

a. With three rings.

b. With two rings and a bar.

c. With two semicircles set back to back.

Type *a* is always hung from a ring. Type *b* is sometimes mounted on a stand. Type *c* always is.

(4) Dials in which the hour is read by the shadow of a point on curves plotted for different declinations. E.g. the Shepherd's or Pillar dials. Cup dials may be included in this class.

(5) The Ring Dial.

(6) Quadrants and Squares of various types in which the reading is obtained by a sliding bead on a string, no shadow being used. There is a large variety of these, some of them being based on projections, though none completely so.

(7) Analemmatic Dials.

Compass Dials

The various forms of Compass dials are more easily classified. But as there are distinct national types, there are advantages in keeping these apart, and also in grouping them according to the

material, whether ivory, wood, or metal, of which they are constructed.

(1) Ordinary Horizontal Dials drawn for a particular latitude, to which a compass is added.

(2) Horizontal Dials in which the plate can be tilted with the gnomon so as to provide for various latitudes.

(3) Horizontal Dials in which the angle of the gnomon can be altered, special graduation being provided for various specified latitudes. This is often known as the 'Butterfield type'.

(4) Book Dials with string gnomon. These usually combine a horizontal with a vertical dial, and sometimes with other dials. This is a very large class; it includes

a. Copper Gilt Dials. *b.* German Ivory Dials.
c. French Ivory Dials. *d.* Modern Wooden Dials.

Some are provided with adjustments for different latitudes.

(5) Equatorial Dials. A very large class.

(6) Elliptical Dials. The hour is read on a movable ellipse. It is found on some of the French ivory dials.

(7) Magnetic Dials in which the dial plate and gnomon are mounted *on* the needle.

(8) Mechanical Dials with clock-work arrangement: usually a form of equatorial dial.

(9) A miscellaneous freak class adapted to the sides of crosses, cubes, spoons, &c.

South Wall Case. Shelves **1–25.**

THE GERMAN SERIES

1. Block Dials.

2. Block and Pendent Dials.

A finely engraved **Quadrate** '*Christianus Heiden, Mathematum studiosus faciebat Anno Christi* MDLIII'.

Circular Dial and **Calendar** by Hartman Korn 1664 most delicately engraved with festoons of fruit and foliage on silver.

Altitude Sundial by Schindler 1716.

3. The German series of Portable **Dials in metal,** and mostly with string gnomons, includes several specimens of the beautiful work of the older masters, of Christopher Schissler 1556, the maker of the fine Geometer's Quadrate in the Bodleian; of Alexius and Ulric Schniep, both of the 16th century, and of others, all of whom worked in gilt, copper, or brass.

4, 9. Ivory folding Dials by Ieronimus Reinman 1558, Johan Gebhart 1561, Ulrich Kliber 1555, Hans Ducher 1567, the Troschels 1580–1640.

5, 10. Seventeenth-century Dials by C. Karner 1622–30, M. Lesel 1629, Paul Reinman 1603–12, Lienhart Miller 1613–50. The series is continued with some unnamed wooden examples and with the pretty **paper dials** of the 18th century. Signed examples by Stockert, D. Beringer of Augsburg, and Negelein of Nuremberg (for the English market).

6. Horizontal Dial (silvered) by Johan Engelbrecht 1776, with a description, in a leather-lined case.

7. Dutch Dials. Examples of engraving of the 17th and 18th centuries on metal. Note the pictures engraved on those dated 1590–1600, and *c.* 1715.

Suspension Dial, nocturnal and compass by *'W. Sneewins fecit Delft* 1709'.

Chronogram Dial with bishop's mitre.
Examples by F. S. P. 1757, and I. Blenaerts à Malines 1770.

8. Folding gilt Dials with string gnomons. M. Purbach 1561–97, Thobias Volkmer of Brunswick 1584, Andrea Mar 1589, Marcus Purman 1596, G. Karl 1598, J. M. Volckmair 1647, M. H. *c.* 1630, Joshua Habermel and others.

The German series is continued in the western Centre Table Case.

(*Centre Compartment.*)

11. Striking **Crucifix Clock** surmounted by a globe showing the hours. There is a sundial on the back of the Cross.

Analemmatic Dial by P. Z. W. S. Ia. 1763.

Gilt Sundial and Nocturnal 1612.

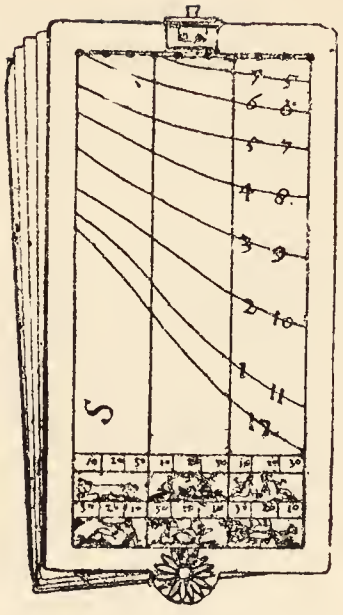
Standing Dial on levelling screws by J. Willebrand.

12. Globe Clock with auxiliary cup-dial hinged above the globe.

Sutton's Quadrant with long sight-rule. London, 1659.

Pendent Sundial and a 'Table shewing the Moueable Feastes for euer'. *Nathaniell Torporley invenit, Charolus Whitwell sculpsit* 1593. Whitwell is known as the engraver of a rare early map of Surrey.

Altitude Dial and Perpetual Calendar. *Johannes Carte, Londini. c.* 1700.

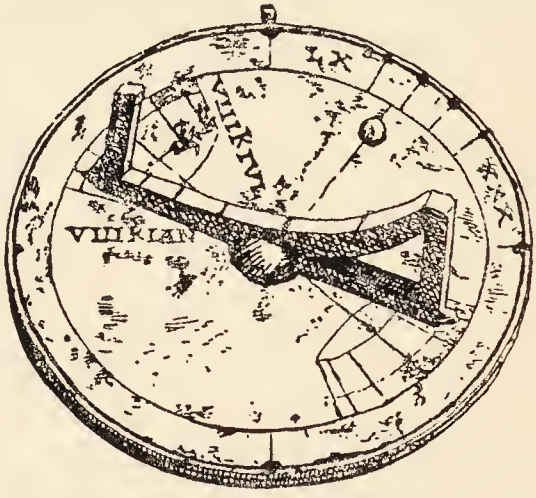


German Pendent Dials on gilt covers of ivory book of tablets, *c.* 1600, and on a flat plate, 1670. The winter times are shown on one side, summer times on the other.

13. Wolsey's Sundial. A polygonal sundial engraved with the arms and hat of the Cardinal, almost certainly designed by Nicolas Kratzer, the first Oxford Professor of Astronomy, *c.* 1520–30. The manuscript description of this dial is preserved in the library of Corpus Christi College, and there are good reasons for believing Kratzer to have been the maker of the dials shown in Holbein's picture of *The Ambassadors,* of which we have a print, presented by Mr. J. B. Carrington.

Ship Dial, *c.* 1500. Probably derived from the ancient Navicula de Venetiis.

Universal Ring Dial with sights for surveying.



Roman Dial of a portable type of the second or third century A.D. The only perfect example known. A circular table of the latitudes of

Roman provinces is engraved on the back of the dial plate.

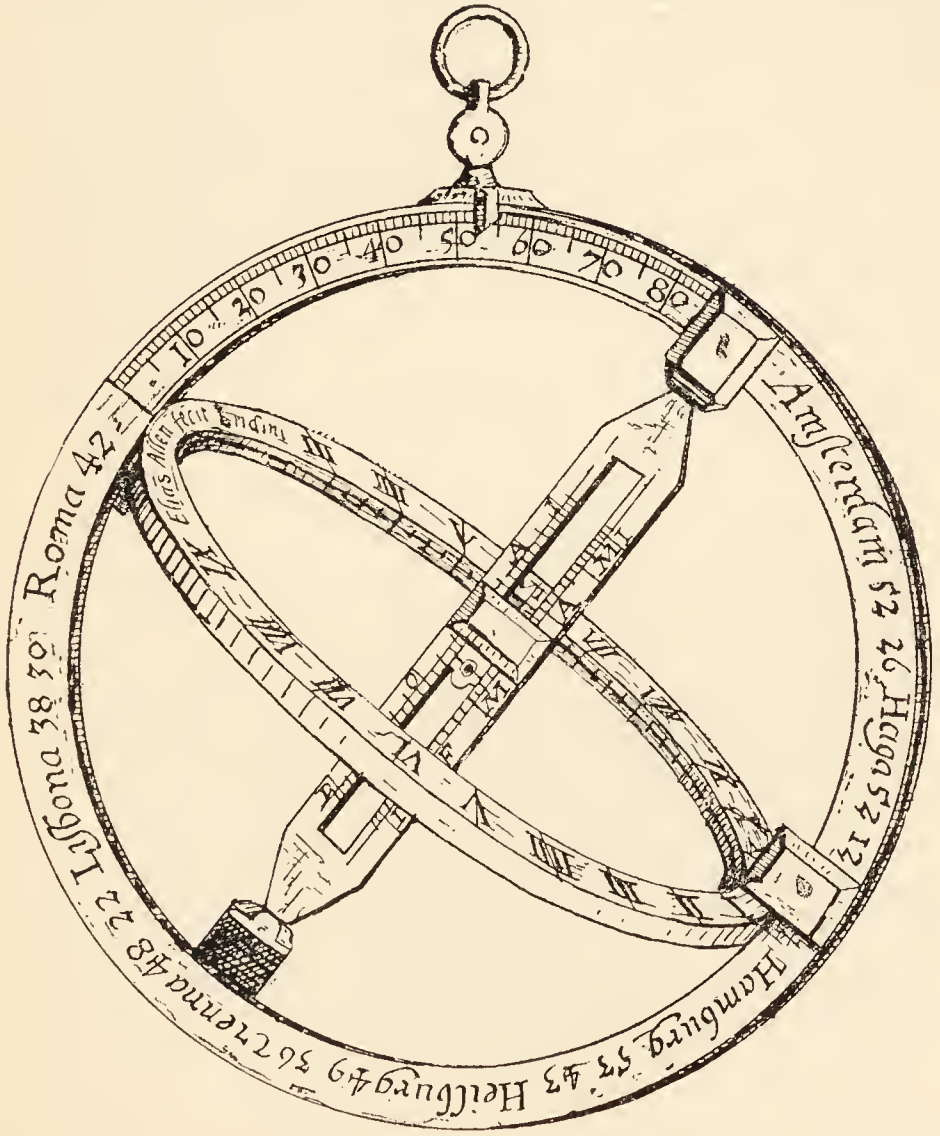
Early Pocket Dial, dated **1481.** Engraved Ave Maria. One of the earliest dials of this type known.

Oval Watch by Gribelin of Blois, with sundial, for use when the clock-work fails.

15. Surveying Compass and Sundial. Marked *C. T. M. F.* 1608.

Universal equatorial dial. Joseph Kodauer 18th cent.

Two-fold Gilt **Octagonal Portable Dial** by Schissler 1557.



14. A finely executed **string gnomon ivory dial** by Christian Heiden. *'M. V. D. Thomae Löffelholtz patricio Norib: cons: in Septu: senatum electo, devotae gratulatio: ergo d. d. Christianus Heide anno MDLXIX octobris XXVII.'*

Two large folding **ivory dials** by Paul Reinman 1599 and Hans Troschel 1618. Book dials by 'Hans Droschel' 1586, 'Hans Troschel *c.* 1630 and C. or A. Karner 1630–45.

The English Series

16. Astronomical Ring Dial by Glynne, *c.* 1750. Numerous examples of these **Universal Dials** are grouped in various parts of this Case. They were extensively used by travellers in the seventeenth and eighteenth centuries. W. Oughtred published a good description of the instrument under the name of the 'General Horological Ring', a work in which Elias Allen is advertised as a maker in 1652.

Two wooden **Quadrants,** *c.* 1640. Inclined Cross dial by Culpeper 1730. Compass dial by Bennett of Cork *c.* 1800.

17. Quadrants by 'R. S.' 1634, C. Parsons 1674, W. Daniell 1663, and one for the latitude of Chester *c.* 1625.

Analemmatic Dial by Thos. Tuttell 1697. **Compass Dials,** including one in a square case made for export to the East in 1790 apparently for use in Ceylon. Modern dial in a small ivory 6-inch rule, 'registered' on the birthday of the Founder of the collection, June 28, 1853.

Hanging **Universal Ring Dials** by Walter Hayes 1680 (silver).

The English Series is continued in the western Centre Table Case. The larger English instruments in the case below include the **Rossipher** by W. Ross 1731, a fine **Universal Ring Dial** by T. Heath *c.* 1745, and a large **Universal Dial** by Culpeper.

Ring Dials, including a fine example of an Elizabethan Finger Ring Dial in silver. One by *Proctor* is engraved

Set me right Use me well and I time tell.

Book Dial by Cole, instrument-maker to Sir Francis Drake, and perhaps the most famous of of all the Elizabethan makers. Inscribed '*Humfray Coole made this boke anno* 1568'.

The **Garden Dial,** dated 1579, shown in the middle of this case is by the same maker. It was for Sir Henry D'arcy.

Two small **Universal Dials** are marked *Car. Whitwell* 1606 (gilt brass) and *Elias Allen* (silver) respectively.

The work of *John Rowley* is represented by a fine **Analemmatic Dial.**

The larger instruments at the back of the case are signed by *T. Wright* London, *I. Coggs* Fleet St. *c.* 1700, *G. Adams c.* 1780, and *Dollond.*

Folding book-dials do not appear to have been as much used as they were abroad, and English examples are not common. A signed **Compass Dial** is by *Samuel Rolfe,* possibly a kinsman of the goldsmiths of Cornhill of that name.

Geared or Clock Dial by *T. Wilks* of Pebworth 1747 with monogram of Lord Litchfield, Chancellor of the University, presented by Viscount Dillon of Ditchley; and another (Univ. Dials) by *William Deane,* presented by Mrs. Lightfoot.

Silver Compass Dial inscribed *Made by C. Harrison in his 85th year his gift of Love to his Grand Daughter Rosetta Hughes 1810.* A somewhat pathetic inscription in view of the fact that no invention had done more to render the use of the compass dial unnecessary than the timekeepers made by his greater namesake John Harrison.

Magnetic Dials by *Fraser* of London and *S. Porter.*

In the *Glass Case above* (*shelf 3*) are some larger **Universal Dials** by *William Deane* and by *Tho. Wright,* with the arms of the Earl of Caithness; and a 'Universal Dial and Dialling Instrument' by *Heath and Wing.*

The Spanish Series

18. Astronomical Ring Dial. *Francisc. de Salvis Roman. fecit Matriti, 1695.*

Brass and Gilt Dials inscribed with the names of Petrus Aggerius, Madriti 1562, and of *Juani Coeart me fe* 1596. **Ivory Dials.**

The Italian Series

19. The earliest are the Herculaneum **'Ham' Dial** (see below, p. 59) and the ancient **Roman Dial** *c.* A.D. 250 already described.

Two examples of **Gilt Disc Dials** with pivoted compasses dated Rome 1585 and 1588. **Crucifix dial** 1575.

Disc Dial and Nocturnal *Ants. Geminus f. Romae* 1589.

Folding Ivory Dial, a quadrant and kneeling Magdalene engraved on the lid. By *F. Joseph a Vin.*

20. Neapolitan casket **Block Dial,** very fully inscribed. Bambini perform the function of gnomons, holding out their hands so as to throw shadows on the hour-lines engraved below. A presentation to a distinguished member of the Tanucci family. Made by *Joseph Maria Cavaliero, Barone Sancti Caetani,* &c. 1770.

Rectangular wooden Dial and Quadrant. *Horologium solare rectilineum quadrangulare universo orbi deserviens, per Mini Pittum Mon[te] Oli[veto] fabre fac.* MDLIII.

Octagonal Cup-dial of wood, *c.* 1600.
$4\frac{1}{2}$ inch quadrant 1611.

Below: A large **Universal Dial** by *Dominicus Lusuerg, Romae, c.* 1700, and a painted box-compass dial, dated 1717.

Scandinavian Wood and Metal Dials.

The French Series

22. Eighteenth-century Dials.

Large **Horizontal Dial** invented by Julien le Roy and made by *Langlois aux Galleries du Louvre.* Dials by P. Aurel, Vienne; J. Pernot, Dunkerque 1785; Le Maire fils Paris. A half ring dial by Chapotot 1730–40. A **Russian Dial** perhaps by a French maker.

23. An early **Circular Dial 15th century.** Portable dial by Thibault 1588, *Rologio Vniversal De Sol, e Lua, e Estrela De Norte,* for use in the East Indies.

Seventeenth-century Dials by Bernhardus, *c.* 1600, Bidault 1650. Dial by Pigeon à Lyon 18th century.

24, 25. Ivory Dials 1580–1670. The French series have a character that is all their own. Those of the earlier dates are beautifully coloured on black as in the earlier types; or in white, red, blue, gold, as in the work of Dujardin, and these lead on to the careful work of C. Bloud of Dieppe and of J. Senecal, both of whom are illustrated by several examples.

Above **24** (hanging) Bréguet's **Cadran d'Equation,** a 'watch' for calculating the equation of time.

Below: A large pendent **Astronomical Circle** with Telescope signed *Canivet à La Sphére à Paris 1762.*

The French series are continued in the Centre Desk Case, W.

French Pocket Dials. Illustrating the highly finished work of *Butterfield, Bion, Le Maire, Macquart, Chapotot, Cadot,* and other prominent makers of the seventeenth and eighteenth centuries. A special feature of these attractive little timepieces is the folding bird-gnomon by which adjustment for latitude is made.

A beautiful little example by *C. Bloud* of Dieppe in a white tortoiseshell case is engraved with the arms of Maria Theresa, wife of Louis XIV.

11-inch Equatorial Dial by *Gaspart à Lisbonne,* presented by Mrs. W. C. and Claude Johnson.

Centre Desk Case West.

PORTABLE DIALS (continued)

Night Dials or Nocturnals

Nocturnals for finding the hour of the night

by the position of the stars of the Great or Little Bear.

The instrument is composed of two circular plates rotatable on a perforated axis, round which a long index rule also moves. The larger plate is marked with circles of hours and of days of the year, and is attached to a handle so that the mid-line of the handle traverses the division for the day on which the star to be observed and the sun have the same right ascension, e.g. if the nocturnal be made for the 'Pointers', the handle must be in line with Sept. 1; if for the γ Ursae minoris, the handle must be in line with Nov. 8.

The smaller plate is divided into $29\frac{1}{2}$ parts for the days of the lunar month. In many instruments it is provided with raised knob-like bosses or with marginal teeth, to allow the hours being counted at night without a light. In use the instrument is set by turning the smaller plate till the mark '12' is against the day of the month on the under plate. Then it is held up with the handle vertical, so that the Pole-star can be seen through the central hole of the instrument. The Index is then revolved until the Guard of the Little Bear (if the instrument be adapted for that star) is on the edge of the Index. Its intersection with the hour-circle shows the time.

The series begins with an elaborate example dated 1557 by *Caspar Vopel* of Cologne, and may be considered to end with the scientifically constructed '*Peripol inventé par Loysel Eclesiastique* 1671'; though in a simpler form, and made of wood, it was much used by English mariners in the 18th century, and figures among the carvings of navigational instruments in the Board Room at the Admiralty. Many Nocturnals were provided with points or knobs, for *feeling* the hour in the

dark—a device that is seen on a small table clock exhibited in the same case.

Chinese Portable Dials

Chinese and Japanese Portable Dials. Interesting as copies or adaptations of Western inventions: some are executed with great skill and reach the high standard of art which these peoples so well understood.

Central Desk Case West.
Glass Shelf 1.

Chilindres or Pillar Dials

The Chilindre or Pillar Dial has been derived from an ingeniously contrived dial of which the origin is to be sought among the Mediterranean peoples. One of the earliest treatises upon it by an Englishman is the *Practica chilindri*, written by John Hoveden, Chaplain to Queen Eleanor the mother of King Edward II.

The editor and translator of this treatise, Edmund Brock, makes out that the particular chilindre described was made for latitude 51° 56′, which was probably intended for the latitude of Oxford. This surmise is supported by a treatise entitled ‘Composicio chilindri cum ejus operacione que facta est apud Oxoniam’, from which we gather that there must have been competent dial makers in the city of Oxford at a very early date.

Indeed, in several of the manuscripts of the Middle Ages it is referred to as the **Oxonian Chilindre.** But we may have to go two centuries farther back, to the writings of Hermanus Contractus (1013–54), to get nearer an origin.

Still the fact remains that we have here the oldest unaltered scientific instrument in the world. The cheap wooden 'shepherd's dials' that can still be bought for a few sous in the Pyrenees might have been made from the fourteenth-century drawing of a Chilindre, or from the seventeenth-century shepherd's dial on Absalom Leech's measuring rod, both of which were given to the Ashmolean Museum by the founder.

In use a hinged gnomon is brought over the proper month indicated by the vertical lines. The chilindre is suspended by its cord, and is turned to the sun until the shadow of the gnomon falls vertically on the column. The slanting lines touched by the point of the shadow tell the time.

Glass Shelf 2.

PENDENT DIALS

Roman 'Ham' Dial. A copy of the bronze original excavated at Herculaneum, and therefore older than A.D. 79.

English Ring Dials. One of the oldest ring dials in this country is one made about 1400, in the British Museum; they were in common use in the seventeenth and eighteenth centuries.

The ring dial consists of a metal ring which can be suspended by a bracket and ring. At a point half a right angle distant from the point of suspension a conical hole is made through the ring, with its apex towards the inside. Through this the sun's rays pass, making a spot of light upon the half ring opposite the hole, which is divided into 90 parts. The sun's altitude can be at once read off from the top end of the scale, or its zenith distance from the lower end.

Equinoctial Dial with geared minute-hand. Gilt brass, by *'L. Platzer in Carlsbaad'*. 18th cent.

Folding Vertical Dial and Compass, by *Alexius Schniepp, Vienna.*

Universal Ring Dial mounted on a stand over a silver compass dial, by *I. Brauchle, Munich.*

Glass Shelf 3.

Geared Dial with wheels and minute-hand invented by *Joseph Ferchel, Königl. Geometer,* and made by *A. Zimmermann.* Ditto combined with an armillary dial by *Johan Willebrand, c.* 1730.

French Window Dial designed by Castel, sécretaire du roi, 1769, and presumably made by *Baradelle,* who made the compass on the instrument. Deposited by Miss Willmott.

Universal Dial by *Antonius Braun* 1716.

(*Middle Compartment.*)

The larger **Dialling Instruments** and **Universal Equinoctial Dials.** The suspended **Astronomical Ring Dials** are by *Willebrand* of Augsburg.

The **English Universal Dials** already described.

German Portable Dials

Compass and Horizontal Dials of the 17th and 18th centuries are illustrated by examples marked 1642; *F. H. Muller* Cassel 1672 (with a perpetual calendar); a finely made example belonging to an engraved **Silver Writing Set**; *J. M. Hager, c.* 1700; and a silver dial made for the

Duke Augustus of Hanover with a **chronogram** for 1722.

Magnetic Dials. The only signed one is by *David Beringer.*

Sundials on Gimbals. Three examples; the oldest being by *I. Christ. Keller, c.* 1590.

Circular Box Dials (17th cent.) with perpetual calendars, astrological tables, list of saints' days, &c.

Middle Desk Case.

Series of several types of the smaller Portable Dials to illustrate the work of a selection of members of the **Augsburg School of Diallists,** including *N. Rugendas, Johan Willebrand, Johan Martin,* and *C. F. Winter,* all of Augsburg. Also the work of *David Beringer, And. Vogler, Claude Dunod* of Dusseldorf, 1716, and others.

A small Dial by *J. P. Rutzius* is worthy of special notice for the distinction of its miniature work.

A series of **Geared** or **Mechanical Dials** are exhibited in the same case; and also **Analemmatic Dials** by *Chr. Schener, Johan Martin,* and a certain '*Masig*' of London, who may really be Willebrand of Augsburg.

Glass Shelf 1 (north end).

English Universal Ring Dials.

One fitted with a circular **Slide-rule.**

Of special interest is the very early square pendent **Dial resembling an Astrolabe** marked with the later name of 'M. Frey'. The hour-lines are drawn on a revolving disc. The gnomon is horizontal.

PERPETUAL CALENDARS

In 1928 Dr. Lewis Evans presented an important series of **Perpetual Calendars** in silver, ivory, wood, and parchment, of various periods and countries. They are for the most part of the circular mechanical, or volvelle, type, by means of which the day of the week corresponding with any day of the month can be readily ascertained. In the more elaborate types the Golden Letters, Phases of the Moon, Time of High Water, &c., are shown. And two years later, in the memory of their father, Mr. J. Dickinson Evans, of Queen's College, and his sisters presented the remainder of the Collection. Owing to the fact that they were made by craftsmen who also made scientific instruments, this long series is useful in helping to assign the latter to their proper epoch and school.

In the same case are exhibited :

Chaldean Calendar from Nineveh, 600 B.C. Cast presented by Mr. C. J. Thompson.

Annulus, of *John of Northampton* A.D. 1328 and 1348. One of the earliest illustrations of a **Clog Almanack** was published by Robert Plot when Keeper of the Old Ashmolean Collections and was dedicated by him to Ashmole (*Nat. Hist. of Staffordshire* 1636). Doubtless it was preserved among our early collections, but has now been removed from the Museum. A second example of this very rare and primitive instrument has been presented to the Old Ashmolean by Dr. Lewis Evans.

Calendar Tokens, A.D. 1716–94.

A **Perpetual Regulation of Time,** 1753–1852,

by *F. Watkins, London,* with barometer with inclined tube.

Dutch **Snuff-box Calendars,** 1729, 1757, 1787, by *C. Norman,* presented by S. Casson of New College, and T. Blockley of Magdalen College.

MATHEMATICAL INSTRUMENTS

Centre Desk Case, E.

Sets of Drawing Instruments

In the sixteenth and seventeenth centuries the smaller instruments were commonly sold in sets, which usually included Compasses with fixed and movable points, a drawing pen point, a pencil point, and sometimes a dotting wheel, ruler, drawing pen, porte-crayon, and protractor.

In the eighteenth century cases for such small sets were made in upright form, and rectangular in cross-section by French makers, but in oval form by English makers. The English cases of the sixteenth century were also rectangular, like those of the beautiful sets of instruments made by Bartholomew Newsum. The idea of the case may have been derived from the knife and fork cases which were introduced about the time of James I.

Set of Italian Instruments in iron, damascened with beautiful arabesques in gold and silver. Fine Milanese work of the sixteenth century. From the Stowe Collection. It was No. 6593 in the Exhibition of 1862. The Proportional Compasses are for the fixed ratios of 1 : 2, 1 : 3, and 1 : 4.

English Sets of Drawing Instruments had a continental reputation during the seventeenth and

eighteenth centuries. It is pleasant to remember that in 1758 'the Making of good Mathematical Instruments is almost peculiar to the English' (Stone's *Bion*).

Of special interest are the early Silver **Disc Protractor** by J. Marke and the large set of **Drawing Instruments** of the period of Queen Anne. Wren's compasses, formerly in the possession of the Royal Society, are of the same style as these, but it is difficult to assign any exact date: it may be 1670–1710.

Note two sets by *R. Glynne*, the larger of silver with gold washers, in a case with a pierced silver engraved platewith a figure of Hercules and Globe. Glynne became a clockmaker in 1705, and was therefore a contemporary of Rowley, the maker of so many of the Orrery instruments. The smaller set is marked with the crest of an owner, a wyvern sitting on a crown. Somewhat later comes the work of *Thos. Heath* who in 1747 had his place of business opposite Exeter Change in the Strand. At the close of the century, *c.* 1790, we meet with sets by *G. Adams* of 60 Fleet Street, here represented by a set including a parallel ruler with a central rule.

Large **Set of Instruments** by *George Adams*, used by Robert Wood (1716–71), who travelled in the nearer East in 1742–4 and again in 1750–1 when in company with John Bouverie of New College and James Dawkins of St. John's College, and the Italian artist Torquilino Borra, he visited Palmyra and drew and measured its ruins. Cf. Hutton, *Travels of 'Palmyra' Wood, J. Hellenic Studies*, 1927.

The mahogany box, deposited by his grandson Mr. Arthur Wood of Great Milton, is marked

with Wood's crest. It contains, in addition to the usual drawing instruments, an elliptical trammel, a three-legged compass, and a pair of callipers for architect's use.

Rather earlier is the **Protractor** by *Sisson.*

Protractors. *Gunter* Type, presented by Sir F. Newdegate.

W. D. Haggard's Double Protractor made by *Bate* of London 1845; *E. Troughton's* spear-headed Double Protractor.

Circular Protractor used by R. Zachariah Mudge, R.E.

Protractors by *Edm. Culpeper, Wm. Parsons.*

Graphometer for measuring angles of crystals by *R. Bancks 411 Strand* 1805; by *Langlois* 1743.

Pantographs by *G. Adams* (29-inch), and by *Cox, London.*

Sectors by *J. Rowley*; *Culpeper, c.* 1700; *Dollond*; *John Allen*; *Geo. Adams, c.* 1750; *W. Deane*; *Heath.*

Scales by *Scott, London* 1820; *Cary, London*; *Jonathan Midgley*; *Measures Bros.*

The **Expanding Grid or Sectograph** for subdivision into equal parts, patented by *Thomas Jones,* No. 38, is a rare instrument of great utility. *c.* 1811.

France is represented by a set of silver instruments by Langlois of Paris, and **Germany** by one by Brander and Höschel of Augsburg (well known by their microscopes and other instruments), and also by the fine sixteenth-century **Crucifix Dial** containing mathematical and drawing instruments, a miracle of close packing.

Geometrical Curves. Set made by Lewis Evans, F.R.S., when instructor at Woolwich.

Elliptical Trammel

The principle involved in the elliptical trammel was known to the Greek geometers. Proclus (A.D. 410–485), of the Platonic school at Athens, in his commentary to Euclid, gave the method for the mechanical construction of an ellipse.

The so-called 'gardener's construction' of the ellipse by means of a pencil and a string tied to two fixed points, was discovered by Alhasan, youngest son of Musa Ibn Schaker, a prominent member of the court of Caliph Al-Mamum, 813–833.

Elliptical Trammel. A second, 19 in. × 8 in., inscribed *Josph Jackson, London,* is in the Orrery Collection.

Clements's Ellipsograph, by *Holtzappfel.*

Oval and other **Chucks and Cutters** for producing **Epicyclic Curves.** by Holtzappfel, 1874.

Calculating Apparatus

Chinese Abacus. Although a modern specimen bought in 1877 by Dr. L. Evans in a Chinese shop at San Francisco, it recalls the older example which was shown in this room nearly 200 years earlier, as a part of the original Tradescant Collection.

Napier's Bones for multiplication and division on the system invented by John Napier of Merchiston (1550–1617), whose portrait is placed next his invention. The oldest set, *c.* 1620, formerly belonged to the Rev. Lewis Evans, F.R.S. A dated set is inscribed *Edmd blow fecit for Mr. Iulius Deedes*

1715. An example of the cylindrical type is dated 1679, by a Perpetual Almanack and Tables of Epacts from [16]79 to 93 on the bottom of the case.

Morland's Adding Machine, dated 1666. A carefully executed piece of mechanism contained between two silver plates, measuring $4\frac{1}{2} \times 2\frac{1}{2}$ in., and pierced with eight apertures for dials for *Ten Thousands, Thousands, Hundreds, Tens, Unites, Shillings Pence, Farthings.* It is fully described in the inventor's book as a means of calculation 'without charging the memory, disturbing the mind, or exposing the operations to any uncertainty'. Pepys, however, wrote rather disparagingly of it. Sir Samuel Morland was Master of Mechanics to Charles II.

Mathematician's Tobacco Box engraved with formulae and numerical constants. '*Revd. Mr. L. Evans 1824*'. It is closely paralleled by the older **Navigator's Tobacco Box** of 1690, kindly deposited by Miss Willmott.

A **Stereometric model** of skilful workmanship is a set of two equal cubes, one of which is dissected so as to permit of the passage of the second cube through it. The work of *L. Evans*, F.R.S.

Slide Rules.

The saying that a prophet has no honour in his own country is well exemplified in the case of the Slide Rule and its inventors. For many years this useful instrument was greatly undervalued in England, the country in which it was invented, and even as late as 1850 it was very little known on the Continent. Yet, as De Morgan has aptly put it, for a few shillings most persons might put into their pockets some hundred times as much

power of calculation as they have in their heads: and the use of the instrument is attainable without any knowledge of the properties of logarithms, on which its principle depends.

In 1620 a straight Logarithmic Scale was invented by *Edmund Gunter* of Christ Church, and calculations were made with it by the aid of compasses. Within two or three years, *c.* 1621, *William Oughtred* is said to have cast Gunter's Line into a ring, 'with another moveable circle upon it', and in 1630 he demonstrated his circular slide rule to his pupil *William Forster*, who in 1632 published a description of Oughtred's instrument under the title *The Circles of Proportion and the Horizontal Instrument*, London, 1632.

Oughtred's Circles of Proportion. This fine instrument was made by *Elias Allen.* It is dated 1635, and is the property of St. John's College.

Thanks to St. John's College and to the Hope Curators we are able to exhibit side by side with this important instrument a portrait of the inventor W. Oughtred, a portrait of the maker, Elias Allen, and W. Forster's own corrected copy of his book upon it, the last belonging to the Evans collection.

Other *Slide Rules* by later makers are contained in drawers in the **Rule Cabinet.**

They include examples of the work of *Rowley, Dollond, Wood and Lort, Saxspeach, Parker fecit* 1753, *S. Waddington, Barnsley,* and a Paper-maker's Calculator by *L. Evans* 1891.

Edw. Thatcher's Slide Rule, 1884.

And among the more recent examples of logarithmic calculating instruments are Boucher's 'Cercle à Calcul', and Saxon and Co.'s 'Automatic Calculator'.

SURVEYING INSTRUMENTS

Measures of Length. Measures of distance, height, and depth were universally made by primitive peoples by direct comparison with arbitrary units of length chosen from parts of the human body. We still retain the names of several of these natural units of length, e.g. the foot, the fathom, the span, the cubit, &c., and the Roman 'passus' is hardly less anatomical in origin. In the Oxford Collections there is a good example of an ancient standard fathom and foot from the island of Samos.

In early days long distances were measured by pacing, a method that was employed by the *Bematists* who accompanied Alexander the Great on his campaigns; and the unit of length, the 'stadion' of 200 steps or 600 Greek feet, was evidently derived from the same practice.

Gunter's Chain, the invention of Edmund Gunter of Christ Church about 1620, is exhibited in the Orrery Case. It is a chain of 100 links, making 66 feet. Two examples came with the Thompson Collection.

Scales of Inches. A number of scales of inches, formerly in use in various towns of Europe, are kept in the Rule Cabinet or are distributed among the other apparatus. A complete set is included in a German Crucifix Dial of the sixteenth century.

Standard Yard and other Measures.

Gauges. Pearl Gauge *John Woode mee fec.* 1627. Gauge for water pipes inscribed *Acqua Felice, Diametri delle fistole.*

Paper gauge for measuring the difference in thickness of sheets of paper.

Waywisers

For the measurement of the long distances necessary for estimating the length of a degree, a carriage wheel was employed by Jean Fernel (1497–1558), who thus readapted the principle of the Greek Hodometer, an arrangement of cog-wheels and endless screws on the same axes, working in the teeth of the next wheels, as described in Heron's *Dioptra.*

The saying, that 'there is nothing new under the sun', is partially illustrated by the invention of **Waywisers,** as early **Taximeters** were called. The first record of them occurs in the *Diary* of John Evelyn. On August 6, 1656, 'I went to see Colonel [Thomas] Blount, who showed me the application of the "Waywiser" to a coach, exactly measuring the miles and showing them by an index as we went along. It had three circles, one pointing to the number of rods, another to the miles, by 10 to 1,000, with all the subdivisions of quarters; very pretty and useful.'

Cary's **Perambulator or Waywiser,** constructed on this principle, is exhibited by Captain Spencer Churchill, under the Mathematical Case.

Waywiser by *Heath,* presented by Viscount Dillon of Ditchley.

Map-meter or Chartometer with printed directions for use.

Eckhardt's **Rolling Parallel Ruler** with watch-face indicator geared to show distances between the lines drawn. Made by P. and J. Dollond of St. Paul's Churchyard.

Major **Everest's Differential Perambulator,**

with two wheels, the back wheel recording miles and tenths, the fore wheel showing thousandths. It is dated Masuri, 15 October 1833, when Everest was engaged in measuring a great arc of meridian of more than twenty-one degrees in length from Cape Comorin to the northern limits of British India. The highest mountain in the world immortalizes the name of Sir George Everest.

Mechanical Counting Instruments

Pedometer by *Johann Willebrand in Augspurg*, executed in gilt brass, with four silver dials, showing units, tens, hundreds, and thousands.

Pedometer by *Steven Hoogendijk Rotterdam*, 18th cent.; and another dated 1667.

Pedometer and **Watch** by *Gout of London* purchased at Dr. Evans's sale and presented by the F.O.A.

Waywiser by *Johan Anton Wisenpainter, Eichstatt*, in a round wooden case, with six dials; with a coat of arms under a ducal coronet.

Registering Thermometer invented and made by Winnerls, mechanician to Paris Observatory.

Instruments for Determination of Standard Direction

Roman Groma, A.D. 79 (Model). Reconstructed from bronze parts excavated at Pompeii. Such instruments were used by Civil Engineers for laying out roads, and for tunnelling, &c. So accurate was their work that tunnels of great length could be started from both ends with the certainty of meeting with but a very small margin of error.

The Vertical

The String Plumb Line. From time immemorial the true vertical has been obtained by the use of a plumb line. As soon as builders began to desire to test their columns and walls for verticality, a string and a stone would have provided them with an instrument capable of more reliable results than mere inspection 'by eye'.

No doubt in time bronze superseded stone as a bob, and eventually in Roman hands lead took the place of both and gave its name *plumbum* to the verb 'to plumb', meaning to test verticality. Finally, in modern instruments of precision, brass has taken the place of lead.

Many examples of the string plumb line may be seen in combination with all Quadrants and some Sundials.

The Balanced Instrument. In the case of some suspension-instruments, such as all astrolabes, cylinder and other dials, the body of the instrument itself is so balanced as to hang 'plumb'; there is therefore no need for a separate plumb line.

The Horizontal

The Plumb Level. By the addition of a T-square to the plumb line, the horizontal direction could be obtained; and the same result was commonly obtained by the suspension of the plumb line from the apex of an isosceles triangle, usually either a right-angled or equilateral triangle. The latter scheme was adopted by Leonardo of Pisa[1] in 1220 for his 'Archipendulum', a massive equilateral triangle with a cord fixed to the apex,

[1] *Practica Geometriae.*

from which hung a plumb-bob—a very 'necessary apparatus for surveying'.

Leonardo's plan is illustrated by several examples in the Mathematical Case.

Small Plumb Levels form part of a very large number of portable dials and were commonly attached to quadrantal clinometers, of which the **Gunner's Levels,** so widely used *in arte bombardica* in the sixteenth and seventeenth centuries, are a particular case. They were used for ranging cannon. Signed examples by '*C.T.* (? *Christof Tressler*) 1616', '*Picart* Cambray', '*Georg Zorn* 1624', '*F. F. F.* 1629', '*M. E.* 1686', '*H R*', '*M. K.* 1689', and *W. Burucker* (pres. by Mr. Claude Fry) '1736', '*Jacques Baradelle* A Paris', and lastly one with a spirit level from a Portuguese gun, marked '*Lisboa arcenal real do exercito anno 1779*' (exhibited by Miss Willmott).

Bubble Levels

Water levels had been used by surveyors ever since the days of Vitruvius (63 B.C.–A.D. 14), who described both 'libra aquaria' and 'chorobates'. In more modern form they were used by Picard (1620-82), Huygens (1629-95), de la Hire (1704), and Römer (1644–1710), but the more compact water-tube level did not come into existence before the second half of the seventeenth century. It was the invention of Melchisedech Thevenot.

At the meeting of the Royal Society on Nov. 28, 1666, 'Mr. Hooke produced a new kind of level, by including a large bubble of air in a glass-pipe, having its sides exactly blown, and filled with water, and sealed up at both ends'. Both tube and circular bubble levels are represented in the Orrery Collection, and there are probably not many,

if any, levels of the circular pattern now in existence, which are older than the Oxford instrument. It is said that spirit was first used in 1775 by Felice Fontana (1730–1805).

Water-tube Level. *c.* 1700. A 9-inch base-plate is supported on two bosses at one end and by the point of a micrometer screw at the other. Two similar triangles are engraved on the plate, the sides of the one marked 8 and 150 being exactly $\frac{1}{3}$ the length of those of the other marked 24 and 450.

Circular Bubble Level. *c.* 1700. Mounted on a base-plate 5 in. diam. by 3 adjusting screws. The centre of the top glass is marked by two concentric rings. This we believe to be the earliest example of a circular bubble level in existence; and though not marked with the name of any maker, it is in all probability the work of John Rowley, who may, provisionally, be regarded as the inventor of this type of level. The view that Rowley was the first maker of such levels is supported by information given by Mr. G. Gabb, that he has seen a universal sundial, made for the Duke of Chandos by Rowley, in which a circular level was introduced.

Wren's Bowl Level was described to the Royal Society on Dec. 5, 1666. It was 'for taking the horizon every way in a circle'. A glass bowl with an accurately turned lip was mounted on a ball-and-socket joint, so that when a drop of quicksilver was adjusted to the centre, the lip should lie level in every direction. Distant objects were sighted by an alidade laid upon the rim of the bowl, and it is believed that Wren used the instrument when he surveyed London after the great fire.

The instrument exhibited has been reconstructed.

18-inch Surveyor's Level used by William Smith, the 'Father of British Geology' when surveying the route of the Great Western Railway.

Geologist's Clinometer, designed by *James Parker* of Oxford and used by him in surveying river terraces in the Valley of the Somme.

Universal Instrument by *Dollond,* used by W. H. Wollaston (portrait) (Conrad Cooke Collection).

Quadrants

The Quadrant series is still very imperfect. At present only photographs are available of the instruments associated with the names of *Sacrobosco c.* 1230, *John of Montpellier c.* 1276, and *Profacius* 1288–1301. Original descriptions and working drawings, given by Ashmole to his Science Museum, were for many years available for study in the Library at the top of the building. A **simple quadrant** of later construction is engraved on the back of the Oriel Astrolabe, *c.* 1340, and an early French quadrant of the type of John of Montpellier, with a cursor (15th cent.) is in the Evans collection. The outer circle of a volvelle is engraved on the back of the latter instrument.

Sinecal Quadrant, *c.* 1450–1500. Pointer collection. Marked TN.

Italian Quadrant by *Francissi di Vectiosi,* 1577.

Italian Quadra Planisphaerii generalis *Io. Antonii Magini.* Maginus was an eminent professor of mathematics at Bologna, *b.* 1536, *d. c.* 1618.

Small **French Quadrant,** 1567.

12-inch **English Gunter's Quadrant,** *c.* 1680.

Prujean's **Oxford Quadrant** *c.* 1670.

The Orrery Collection contains dated examples by *Sutton* and an ivory quadrant by *Rowley* mounted on a stand.

Surveying Instruments of the Sixteenth and Seventeenth Centuries.

The Oxford collections of surveying instruments cannot be considered satisfactory until the **Cross-staff, Back-staff,** and **Cross-bow** are well represented. Forms of Cross-staff and Cross-bow are associated with Edmund Gunter of Christ Church; the Back-staff was invented in 1590 by Captain John Davis, the Arctic navigator, who had been greatly troubled by the sun in his eyes at low altitudes in high latitudes.

The **Cross-staff** and **Cross-bow** associated with *E. Gunter* are represented by models; as also is *Digges's* Cross-staff of 1558.

The **Back-staff.** A good specimen was presented by Dr. E. B. Knobel, P.R.A.S.

The evolution of reflecting Octants and Sextants from Hooke's original suggestion in 1666, to Newton's Reflecting Octant, *c.* 1700, and to Hadley's Octant in 1731, is only illustrated by drawings. But of the complete instrument, the **Mariner's Sextant,** there are several examples, with and without telescopes; also in a miniature form, and in the well-known box form. An early type was made by G. Brander and Höschel of Augsburg.

The invention of the sextant brought about the final extinction of the Astrolabe.

No instrument, except the compass, has been a greater boon to navigators, and it is satisfactory to note that, as in the case of the mariner's com-

pass, an Oxford man has taken a prominent part in its early history.

The **Theodolite** in its modern form is the outcome of a large number of inventions by the gradual combination of which an instrument of great power has been made available for the purposes of the surveyor. The principal improvements have been made by Englishmen, and the first undoubted theodolite[1] was constructed by Leonard Digges of University College, several years before it was described in detail by his son Thomas in 1571.

The **Theodelitus of Digges** had a horizontal circle divided into 360°, and a vertical semicircle divided into 180°, with an alidade or index, bearing sights for measuring vertical angles.

Digges's method of using his instrument is clearly shown in his book by an engraving which, moreover, indicates that his invention was intended to meet the artillerist's need of estimating the range of the objective of his fire rapidly and accurately. This early association of the chief topographic instrument with accurate gunnery is preserved in the name of our State Survey Maps, which are still known as Ordnance Survey Maps, although happily they are now less needed for military purposes than for those of peaceful landed proprietors.

A year ago no example of a theodolite, dating from the sixteenth century, was known, at any rate not in Oxford, but Mr. Last has recently found an important instrument in the Library of St. John's College, which may be identified as part of an

[1] The word theodolite is a favourite word with the composers of examination papers in which unusual derivations of words are asked. *Theodolite* = *theodelite*, a corruption of *athelida* which was a corruption of *alhidada*.

original instrument from which the Bleau Theodolite of 1664 has been derived. After cleaning off the dirt of ages it was found to be inscribed with the name and date of the celebrated maker, '*Humphrey Cole, 1586*', who lived during the lifetime of Digges, and is known to have made use of Digges's writings. We have therefore no hesitation in naming Cole as the first-known maker of the Theodolite.

The complete instrument as it left Cole's atelier may not have been unlike the theodolite figured in Bleau's *Atlas*.

Circumferentors.

To meet the special needs of land-surveyors the *Surveying Compass* or *Circumferentor* was devised. One of an early type is associated with the Italian Tartaglia in the middle of the sixteenth century, and from this the later models appear to have sprung. In 1607 J. Norden states that 'Circumferentor' is a new name given to the very Theodolite, 'used in a sort otherwise then the Theodolite'. The compass box in the centre was considerably enlarged.

Several Circumferentors are shown in the case of Surveying Instruments, also a large complete example of English work by I. Worgan, with its tripod, in the Orrery Case.

Surveying Compass and Sundial.

Brass gilt, mounted on a wood base. Inscribed: 'C · T · M · F · 1608', perhaps, '*Christof Tressler Mechanicus faciebat*'. The $12\frac{3}{4}$ inch sight-rule is engraved with a Diagonal Scale.

An early example by an Italian maker is marked 'LVD · SEM · FEC · A · D · 1612'. A circular plate, $5\frac{1}{2}$ inches in diameter, carries pillar-like sight-

vanes rigidly fixed at right angles. Another, from Prag, is inscribed 'IOHANNES THVRNNER FECIT PRAGAE 1679'. It is brass gilt; with a small compass, $1\frac{1}{4}$ inch diameter, mounted on gimbals, and furnished with two sight-vanes only.

The Orrery **Circumferentor,** *c.* 1690, is by *I: Worgan.* It has a circular base-plate of 13 inches in diameter, with a border divided into $\frac{1}{2}$ degrees. The compass box contains a 4 in. needle. The upper ends of the legs are noteworthy, being expanded like those of the early forms of wooden tripods.

Three **Italian Circumferentors** of the 17th century.

Circumferentor by Maulevant of Paris, *c.* 1720.

Circumferentor by Tho. Wright '*In*^{t} *Maker to the Prince*'.

Graphometre by Baradelle.

Surveyor's Set of Instruments in a small leather trunk. The set includes a fine pendent semicircle divided to half degrees, each being again divided into $\frac{1}{5}$ths by transversal rows of dots. Dutch or Flemish work.

Surveying and Levelling instruments by T. Volckmer, goldsmith to the Duke of Bavaria, 1612.

In the same case are shown a **Compass and Dialling** Instrument inscribed *Lusnerg Mutinensis faciebat Romae* 1668 and a large **Equatorial Dial** by *Cole, Fleet St., c.* 1760, and also **Surveyor's Sectors,** two by Blondeau and Butterfield respectively.

Wybard's Scalae Agro-graphico-metricae 'for the most accurate plotting of land'. *W. Hayes at the cross Daggers in Moore feilds Londini fecit. c.* 1670.

Descroliere's Surveying Instrument, 1579.

The **Joint Rule** by *Christof Tressler der Elter Mechanicus,* Anno 1617, is of interest on account of its special slider, moving over oblique lines by which distances are readily measurable to a very small fraction of an inch. A similar device was adopted about a century later by Rowley for a Gunner's Scale (Orrery collection No. 61).

The Plane-Table

By plane-table survey a graphic representation of a country can be obtained without the necessity of trigonometrical computations. The method of laying out angles by direct observation is of so simple a nature that we cannot but believe that it was used by the geometers of antiquity for constructing plans. However, in reconstructing the history of our modern methods, we can go no farther back than 1597, when one Phillip Danfrie of Paris invented the **Graphometre.** His invention is represented in the Orrery collection in a complete form of about the year 1690 and mounted on a neat folding tripod $4\frac{1}{2}$ feet in height.

The Orrery **Graphometre** is provided with a special sighting arm which was not a part of Danfrie's original instrument. The observed angle between the alidades could be directly transferred to, and drawn on, a plan, either by the superposition of the instrument, or else by means of a graduated and hinged rule, which is shown in the original engraving of the Graphometre.

The Orrery **Plane-Table** is the earliest known British example. The maker's name and date are clearly printed on the compass card, which, as is usual, is reversed. *Iohn Worgan Londini fecit* 1696. The folding frame, graduated in degrees,

and scales of inches, is stamped with fleurs-de-lys in groups of three. The alidade is engraved with the usual plotting scales, and with Gunter's lines of Numbers, and lines of Sines and Tangents.

John Thompson's $18\frac{3}{4}$-inch **Plane Table and Tripod,** inscribed *Made by G. Adams in Fleet St. London. Inst: Makr: to His Royal Highness the Prince of Wales.* The magnetic compass with card by the same maker is of figure-of-8 shape and is only graduated for 45° on each side of the North-South line. It was built to Thompson's design (only example known) and is the finest plane table which we have ever seen, not only for its consummate workmanship, but because of a special tilting arrangement on the head, by means of which the table can be fixed in a vertical plane, or at any angle with the horizontal; and also by reason of the scales, marginal sights, and adjustable rules, which can be raised by adjusting screws above the surface of the board, or be sunk flush with it.

It is accompanied by a Drawing Board, $22\frac{3}{4}$ inches $\times 20\frac{3}{4}$ inches, with marginal scales, and adjustable tee-square.

The **Alidades** for Plane-Tables, in the Evans Collection, are by *B. Scott* (two), *Langlois à Paris,* and others without signature.

$19\frac{3}{4}$-inch **Alidade** by *George Adams* for Lord Dillon.

The Eighteenth Century

During the eighteenth century the ever-increasing need for accuracy in astronomical instruments led to the addition of great refinements of construction and to the superposition of auxiliary

apparatus for the elimination of errors of observation.

Two important collections illustrate the Surveying Instruments of the seventeenth and eighteenth centuries. The earlier series belonged to Lord Orrery and are exhibited together in the Orrery Case, *v.* p. 22. The seventeenth-century collection belonged to John Thompson, a land surveyor of Witherley in Leicestershire (1722–83). His oldest telescopic level dated 1724 may have come from his mathematical instructor.

The character of the work done by such instruments is indicated by the Survey books of Thompson's son Ralph and by a large survey on parchment of the Rich estate near Sonning. The manor of Sonning was sold by Sir Thomas Rich to Richard Palmer in 1795.

16-inch **Circumferentor** (no stand) graduated to $\frac{1}{3}$ degrees in one quadrant only, and signed *J. Search, London.*

Several **Telescopic Levels** are exhibited in the Surveying Case. The earliest belonged to John Thompson. It is fitted with a 13-inch telescope and a 5-inch level with a micrometer screw adjustment at the side, inscribed *Made by Tho. Wright, Instrument maker to His Royal Highness the Prince,* 1724.

Surveyor's Level—not signed—with $9\frac{1}{4}$-inch telescope on a semicircle of $3\frac{3}{16}$-inch radius, probably also by *T. Wright.*

The application of newer knowledge to the manufacture of a scientifically constructed theodolite is mainly due to Ramsden. This famous instrument-maker had in 1763 invented a machine for dividing circles with greater precision than any that had hitherto been graduated. These circles

and all the refinements of an astronomical transit instrument, Ramsden introduced into a new theodolite, which was first used on the triangulation of England in 1787, when the triangulations of England and France were connected for the first time.

Miner's Level by *Wilton* of St. Day, Cornwall.
Theodolite by *Thos: Jones.*

Natural Magnets

Magnetic oxide of iron is now known to be widely spread over the globe as a natural mineral, though formerly it was almost exclusively derived from Magnesia, Lydia, and the island of Elba. Isolated fragments, or 'lodestones', were valued in very early times for their power of attracting iron, yet they are not known to have been described as stones 'with which an attraction can be given to a needle' before A.D. 121. Oxford is now the possessor of a fine series. First and foremost comes the large **Lodestone** presented to the Ashmolean Museum in 1756 by Maria, Countess of Westmorland. It is contained in a case resembling a coronet. Its total weight, with case and two iron poles, is 171 lb. The armature supports a weight of 163 lb., and is said to have acquired an additional lifting power of 25 lb. since it was first placed in the Ashmolean Museum. There is an engraving of it at the end of the *Catalogue of the Ashmolean Museum*, 1836.

The beautiful and costly mountings of the Lodestones in the Evans Collection show the value set on these objects by their owners in the sixteenth and seventeenth centuries.

The magnetic properties of ten of the specimens exhibited may be summarized as follows :

The Evans Collection of Lodestones and Compound Magnets.

Date.	Description.	Size in inches.	Weight.	Lifted. lb. oz.	Date.	Times own weight.
c. 1730	Gold mounted	$\frac{7}{8} \times \frac{1}{2} \times \frac{5}{8}$	$\frac{5}{8}$ oz.	– $4\frac{1}{2}$	in June 1909	= 7·2
	Gold mounted	$1\frac{1}{8} \times \frac{15}{16} \times \frac{11}{16}$	$2\frac{3}{4}$	– 19	,, Feb. 1912	= 6·9
c. 1600	Silver mounted	$\frac{5}{8} \times \frac{3}{8} \times \frac{1}{2}$	–	–	–	–
1720	Cased in Silver	$1\frac{5}{8} \times 2\frac{3}{8} \times 1\frac{1}{2}$	$15\frac{1}{2}$	1 7	,, 1907	= 1.44
1700?		$1\frac{7}{8} \times 2\frac{1}{4} \times 1\frac{3}{16}$	$9\frac{3}{4}$	– $10\frac{7}{8}$	,, 1909	= 1·115
c. 1750	Terrella	Diam. $1\frac{13}{16}$	$7\frac{1}{2}$	8 –	,, 1914	= 17·0
	French : Silver mounting	$1\frac{5}{8} \times 1\frac{3}{4} \times 1$	$8\frac{5}{8}$	1 $13\frac{3}{4}$	,, 1907	= 3·425
1741	Russian :	$1\frac{3}{8} \times 1\frac{3}{4} \times 1\frac{1}{2}$	$8\frac{3}{4}$	1 $4\frac{1}{4}$	,, 1907	= 2·31
17th cent.	Mounted in Finger Ring	$\frac{5}{16} \times \frac{1}{4} \times \frac{1}{4}$	–	– $\frac{5}{8}$	,, 1912	–
1790 [1]		$5 \times 3 \times 2\frac{3}{4}$	6 lb.	8 4	,, 1915	= 1·3
	Compound Magnets.					
c. 1730	7 flat bars	$4\frac{1}{2} \times 1\frac{1}{8} \times \frac{1}{2}$	–	– $14\frac{1}{2}$	,, 1909	–
c. 1800	2 horseshoes (Sir J. Evans)	–	1 lb. 4 oz.	2 $4\frac{1}{4}$	,, 1909	= 1·8
c. 1740	Like a lodestone	$2 \times \frac{7}{8} \times \frac{3}{16}$	–	–	–	–

[1] Remagnetized by Professor Silvanus Thompson, F.R.S.

In the seventeenth century lodestones were commonly carried to restore polarity to the compass needles of sundials, as well as for more occult properties. The most interesting example in the collection is undoubtedly the **Terrella,** not only on account of the rarity of such forms of lodestones, but on account of their historical association with Charles II and the early members of the Royal Society, who were able with the aid of a Terrella and of a few small iron rods representing men in miniature, to study and visualize the problem of antipodes.

Magnetic Compass

Many nations, the Chinese, the Arabs, the Greeks, the Etruscans, the Finns, and the Italians, have each in their turn been credited with the discovery of the Compass. There has been a tendency to push the invention of this instrument farther and farther back into the past, and thus it has acquired a mythical origin in which all record of the real inventor has been lost. So though as remote an antiquity as 2634 B.C. has been attributed to the compass of the Chinese, the first authentic record of a Chinese marine compass is no older than A.D. 1297, three centuries after the floating compass was in use among the citizens of Amalfi.

It has recently been argued that the 'South Pointing Chariots' or Indicators of the South, which were used by the very early Emperors of China on their journeys, and have been supposed by Padre Bertelli and others to have been magnetic needles, were merely mechanical contrivances used for indicating the south, which depended for their orientation on cogwheels rather than upon magnetism. In its construction the Chinese

compass differs from the European instrument in having a mark upon the south-seeking pole of the magnet instead of upon the north, and in having the compass dial graduated into 24 points, starting from the South Pole. Specimens of such instruments with short and very sensitive needles are exhibited in the East Table Case.

The floating type of compass was undoubtedly much used in the East at an early period. Navigators in Indian waters were said to use 'a sort of fish made out of hollow iron, which, when thrown into the water, swims upon the surface, and points out the north and south with its head and tail'. And in 1242 the magnetized needle, floated on water by a piece of wood, was employed by seamen in the Eastern Mediterranean, and by the Italians, whose name *calamita* has been supposed to have been *derived from* καλαμίτης, a frog, and thus to be a memento of their early practice.

The first-known mention of the polarity of the magnet in European literature is in the writings of the Arab geographer Edrisi (*c.* 1099–1154). The earliest diagram of a pivoted compass was preserved in the Ashmolean Building for 200 years, but has now been removed. It illustrates a MS. by Peregrinus de Maricourt.

The names of several Oxford men are remembered in connexion with the magnetic compass. One of the first was William Barlowe (*c.* 1544–1625) of Balliol College, who has the distinction of having printed in English the word *magnetisme* before any one else. Edmund Gunter of Christ Church showed that the measure of Magnetic Variation itself varied 'in various parts of the ground'—an observation that led to the discovery of 'Secular Variation of the Variation' (as the Declination was then called). The early members

of the Oxford Philosophical Society and of the Royal Society performed many experiments on magnetics, which greatly furthered our knowledge of terrestrial magnetism, and resulted in the construction of a magnetic map with lines of equal variation by Edmond Halley of Queen's College. Towards the middle of the eighteenth century great improvements were made in the making of strong magnets by two members of Magdalen, Servington Savery and Dr. Gowin Knight. So successful was the latter that, like Lord Kelvin in after years, he practically held for a time the monopoly of making compasses for the Navy. An example of the **Kelvin Compass,** which owes its superiority to a system of very light needles grouped parallel to one another, is exhibited on the main staircase.

A selection of compasses and compass cards is shown in one of the centre Table Cases.

Compass Card bearing the name of *Gowin Knight* whose portrait is exhibited alongside of his invention.

The **Chinese Compasses,** used by Geomancers, include two that were taken by Captain Lefroy at the siege of Pekin in 1857 and an older example presented by Major-General Sir Neill Malcolm, K.C.B., with a Chinese text-book explaining the use of the complicated scales that surround the compass box.

Next the Chinese Compasses, are a **Japanese Compass,** mounted on gimbals, and a **Japanese Meridian Compass** in an ebony case beautifully inlaid with mother of pearl.

The **English Series** includes examples by the following makers:

'*John Sellers*' *c.* 1660, on an engraved dial

embellished with allegorical figures. The dial is of those of early type in which the East point is specially distinguished.

'*Henricus Sutton Londini fecit* 1661.'

'*Will. Collier, Fec*^{t}.' formerly owned by '*Christopher Earle* 1712'.

'*John Bennett London*' *c.* 1710 : an instrument that formerly belonged to Lewis Evans, F.R.S.

'*B. Martin*' *c.* 1750, on a compass card with a map of the Atlantic Ocean.

The compass by Sutton belonged to a plane-table, for the dial is printed with the East and West points **reversed,** for convenience in reading observations of compass-bearings, measured either east or west of the North-South line. A similar example by Worgan is in the Orrery Collection. The earliest instance of a reversed compass dial may be consulted in a work by Agricola, who wrote in 1556.

The well-known surveying instrument, the **Prismatic Compass** is said to have been invented by *Schmalcalder* about 1812; the exhibited series includes examples by him, by *Thomas Jones, Troughton & Simms* and *Negretti & Zambra.*

Hanging Compasses, in rectangular ivory or wood boxes furnished with hooks for hanging from stretched cords, were used in conjunction with small pendent plumb levels by mining engineers. One of these 'miner's compasses' in ivory is dated 'H.W. 1689'.

GLOBES

LOBES have formed part of the equipment of every well-appointed library from the earliest times. The Cairo Library *c.* A.D. 800 boasted 'two fair globes, the one of brass, the other of silver', and they were almost certainly celestial globes.

After the time of Bede, when celestial globes formed part of the educational apparatus of monastic schools, globes were made in 929 by Gerbert of Aurillac, and by the skilled craftsmen employed by Alphonso the Wise, who described their manufacture in 1252. They were necessary for early demonstrations on the Sphere. But there is no record of any terrestrial globe at this time.

The Arabs likewise produced celestial globes only: the oldest now extant, made at Valentia, is to be seen in the Museum at Florence.

Cufic Arabic Globe, A.D. 1362. Made by Jaafar ibn Omar ibn Dauletshah al Kermani in the year 764 Hegira. Bronze, 6 inches in diameter; with engraved figures of the constellations; the stars are represented by inlaid silver discs, corresponding in size to the magnitudes of the stars. Supported by a four-legged, circular stand on which its axis can be adjusted to the Pole of the Equator, or to that of the Ecliptic, with further adjustments to every 10° of North Latitude. The Figures of

the Constellations show Chinese influence. Dr. Knobel notes that all the constellations are Ptolemy's, and that he has been able to obtain a most satisfactory confirmation of the date by the longitudes.

Two relatively modern **English globes** (by *J. and W. Newton* and *S. C. Tisley,* the latter presented by Mr. S. Casson of New College) are shown in the same case. The former is turned so as to show the Southern Constellation, *Machina Pneumatica,* i.e. Boyle's Air Pump, translated to the heavens (see p. 99). In the Tisley globe it has become a two-barrelled '*Air Pump*'.

Celestial Globe by *Dudley Adams,* presented by Miss H. Jackson.

Terrestrial Globes are a much later invention than the Celestial, although many early men of science were aware of the rotundity of the earth. Owing to lack of space it has been impossible to gather together a representative series of Oxford globes. Yet there is much to be said for the advantages of comparative study, which is only possible through juxtaposition.

The oldest globe now extant in Oxford is the hemisphere of 1624 on the monument to Sir H. Savile in Merton Chapel.

Sanskrit Globe of the Earth, 1571, presented by C. Cobb.

The small **Terrestrial Globe** by *I. Senex* shows the 'Antipodes to London'.

Below is 'A New Portable Orrery' by *W. Jones.*

It is interesting to compare the constellations on the Persian and English globes with those on the adjoining cast of a **Chinese Planisphere** or Map of the Heavens, taken from a Japanese junk wrecked

on the volcanic island of Vries off the coast of Japan. The stars are indicated by raised dots linked together to form Chinese constellations. On the rim are engraved the names of the twelve so-called *Branches* which denote both the months, and the Chinese hours (each of 120 minutes), and the points of the compass.

H. Sutton's **Planisphere** of 1659.

Volvelle by *Rodes Brechte,* belonging to St. John's College.

THE ORRERIES

An **orrery** is a machine for representing by wheel-work the various motions of the heavenly bodies. This machine differs from a Planetarium in that it exhibits diurnal as well as the annual motions of the earth, the revolution of our moon, and sometimes the rotation of the sun and of certain planets on their axes. The larger instruments, called 'Grand Orreries', exhibit, moreover, the motions of the secondary planets, but more particularly those of Jupiter.

By the orrery it is possible to represent all the vicissitudes of summer and winter, of spring and autumn, of day and night, the risings, settings, and culminating of the heavenly bodies, together with their constantly varying altitudes and azimuths, their right ascensions, declinations, and amplitudes, their conjunctions and oppositions, their transits and occultations or eclipses. The orrery is therefore a machine of the first importance as a means of education in planetary motions.

The manner in which the instrument came by its name is due to several coincidences. Before

the year 1715 an instrument was contrived and made by GEORGE GRAHAM, which represented at the same time both the annual and diurnal motions of the earth, and also the synodic period of the moon ; these motions had never before been exhibited together by any mechanical contrivance, at least in England. The instrument was put into the hands of a workman to be packed and sent to Prince Eugene. Whether this workman was Rowley, or some other person employed by him, does not appear ; but it is said that Rowley, getting ideas from the model, made a machine for the Earl of Orrery, with additions of his own invention.

The special connexion of the cabinet of philosophical instruments at CHRIST CHURCH with the LORD ORRERY in whose honour this elaborate form of planetarium has received its name, and the acquisition by Christ Church of an orrery by Thomas Wright, gives this complicated piece of mechanism a special local interest.

The **original orrery** made by Rowley did not come to Christ Church with Lord Orrery's other scientific apparatus, but remained in the Orrery family. The case was 12-sided, constructed of ebony with 12 silver signs of the zodiac in the twelve panels.

There are three large orreries in Oxford. The oldest dated 1731 was the one made by Wright, already mentioned. The second, belonging to Queen's College, is contained in a beautiful case in the style and period of Chippendale. It was made about 1750 by B. Cole & Son, whose place of business was, appropriately enough, '*At the ORRERY, Fleet St. London*'. The third, or Grand Orrery by Heath and Wing, belonging to All Souls College, comprises the orbits and moons

of Saturn, as well as of Jupiter, and is driven by an efficient clock and elaborate trains of cog-wheels.

By permission of the respective Colleges these three instruments are now on exhibition with the Evans Collection.

MECHANICS, PNEUMATICS AND HYDROSTATICS

Experimental Philosophy was certainly being taught by some of the College Lecturers at the time of the foundation of the Old Ashmolean, but several years elapsed before such courses of Lectures were given in the building itself. For instance JOHN KEILL was lecturing in Hart Hall from 1700 onward, and with such success that he 'introduced the Love of the Newtonian Philosophy' into Oxford. To him in 1710 succeeded JOHN THEOPHILUS DESAGULIERS, who, being an indefatigable lecturer, spread the new Philosophy among persons of all ranks 'even among the Ladies'. The Ashmolean soon took up the work from 1716–28 J. WHITESIDE carried on a course of experiments with £400-worth of apparatus and to the 'great advantage of the youth of the University'. In 1729 BRADLEY purchased the apparatus for £170 and gave many courses to classes each averaging 57 persons. I have seen the box that he then used to illustrate the doctrine of aberration of light, but it has now been lost in the Clarendon Laboratory of the New Museum. Two guineas were charged for a course.

Dr. Thomas Hornsby put out regular advertisements of his Lectures on Experimental Philosophy between 1766 and 1775, but of the apparatus which he may have used, none survives to-day, which is a pity, because few exhibits in an historical museum are of greater interest than those which illustrate the anticipation of later inventions by early experimenters. Several instances of this are illustrated by photographs showing side by side the old and the new taken by Professor C. Andrade and presented by him to the Museum. They include the **Rotary Pumps** of Prince Rupert (17th cent.) and of Gädke (20th cent.).

It may have been from one of Bradley's lectures that Dr. Edmund Cartwright, F.R.S., acquired those mechanical tastes that he later applied to the good of mankind by the invention of the **Wool-combing Machine,** of which we ought to have a model in Oxford.

Turning Lathe

5-inch Centre Lathe by *Holtzappfel,* No. 2278, originally purchased by Mr. Angell in 1874, from whom it passed successively into the possession of Mr. Gurney 1880, Lord Brooke 1887 and Lord Cairns 1895. It is furnished with overhead motion and a traversing mandrel, division plate and segment engine, on a double frame of mahogany. The accessory apparatus includes in addition to the usual chucks, a slow motion apparatus, Atkinson's Reciprocator, Eccentric, Oval, Rectilinear, Spherical, and Oblique Chucks, and Rose Apparatus; Slide Rests for metal, ornamental and spherical turning; eccentric, universal, vertical and horizontal Cutting frames; the Elliptical apparatus designed by Major James Ash; Rose cutting frame; Goniostats and

Grinding apparatus, and sets of hand tools in mahogany cupboards. Presented by Miss E. Willmott.

Medallion Engine, the invention of *Jessie Lowe,* of Bolton, as described in the *Quarterly Journal of the Amateur Mechanical Society,* Vol. I. 1871.

It was with lathes of this kind that T. H. Toovey Hopkins, and Edward Chapman, fellows of Magdalen College, did much of their work.

Geometric Chuck, and book of printed designs by Sir Charles Taylor belonging to R. Gunther are on loan in an adjoining case.

MECHANICAL APPARATUS

The earliest mechanical apparatus now extant amongst us are the **Worm-Jack Steelyard** and **Pulley blocks** in the Orrery Collection. But the Oriel Collection is far richer with its educational models by Nairne and **Vauloue's Engine for Driving Piles** of Westminster Bridge. Cf. Ferguson's *Lectures* 1805.

Apparatus for Experiments on the Mechanical Powers

Brass Frame with **Levers** and four sets of **Pulleys,** *c.* 1780.

Brass Frame with **Worm-wheel and Tangent Screw and Inclinable Plane** with accessory apparatus. Both instruments were made by Nairne on the lines of the apparatus depicted in the plates to Ferguson's *Lectures* 1776.

Weights and Measures

Set of **Egyptian Weights,** presented by Professor Sir Flinders Petrie.

Set of **English Cup Weights** used in the Old Ashmolean Chemical Laboratory in time of

Dr. Robert Bourne, presented by his grandson, Professor G. C. Bourne.

Large Set of **Cup Weights** in case with ornamental hinge and fastenings, presented by Friends of Old Ashmolean.

Copper Beam of **Egyptian Balance,** presented by Professor Sir Flinders Petrie.

Hawksbee's **Specific Gravity Balance.** St. John's College Library.

Ashmolean **Chemical Balances** by Corless, Magdalen College. Platinum beam scrapped by Mr. J. Manley during the Great War 1916.

Chinese **Dochin,** formerly used by Charles Hatchett, F.R.S.

English **Dochins,** *c.* 1700, Poynter College; and by *B. Martin,* 1756.

Antique **Bismar,** obtained in Faroë Islands by Mr. A. Dodds-Parker.

Steelyards of brass and wood.

Sets of **Guinea Scales and Weights. Apothecary's Scales** of W. Blagrove of Abingdon; and by *Anderton of Birmingham,* 1810.

Balance by *De Grave,* 1821, used in Magdalen College Bursary.

Chondrometer or Corn Balance.

Bradford's **Patent Balance,** presented by Mr. J. D. Evans.

Mills

Hand Stone Mill, presented by Mr. Spokes. The hursting is of oak, and is marked A.S. 1745. Two crank handles are provided for driving the mill, one on either side of the hursting. The horizontal shaft carries a wooden toothed wheel, with thirty peg-cogs, which engages with a

wooden pinion (fourteen cogs) on the stone spindle. This spindle passes through the centre of the bed stone, and drives the runner stone in the usual way. The stones are about 22 inches in diameter, and are furrowed in exactly the same style as an ordinary pair of power-driven stones. It will be noticed that the spindle rests upon a movable bridge-tree, which allows the wheels to be thrown in and out of gear. At one side of the stones is the meal spout.

There is evidence that mills of this description were built in the eighteenth century, obviously with the hope that farmers would buy them for grinding their own corn for their own household and for their farm hands.

William Emerson (1701–82), the mathematician, son of Dudley Emerson, describing a hand-mill of his own contrivance, calmly observes: 'It is a pity some such small mills are not made at a cheap rate for the sake of the poor, who are much distressed by the roguery of the millers', but his mill (*Encyclopaedia Britannica*, 1795) did not survive to effect the contemplated end.

A popular writer at this time sarcastically remarks (*London Magazine*, March 1758): 'There seems a great inclination on people to buying their own corn and grinding it with these newly invented handled mills, lest they should be poisoned or cheated', and numbers of hand-mills were put before the public at this time.

Cf. also Richard Bennett, *History of Corn Milling* (p. 223, vol. i).

To another series belong instruments for measuring the velocity of currents of water and of the wind, one of which was used by Edw. Chapman, M.P., of Magdalen College, and related to it is a **Smoke Jack** made by *Gill & Co. of*

Oxford, which until recently was in use in the kitchen of Corpus Christi College. Such simple mechanical means of utilizing a waste product, the hot air rising in a kitchen flue for turning spits, were employed in most Oxford Colleges, but the installation is now in regular use in Pembroke and a few other Colleges.

A series of photographs of local Oxfordshire **Tower and Post Windmills** taken by Mr. H. M. J. Underhill has been presented by his sister.

Clocks and Clockwork

The oldest example of **cog-wheel gearing** is contained in a Persian Astrolabe dated 1223 for working a calendar movement, but we have no note of the association of any Oxford man with a clock before Richard of Wallingford, the constructor of the Abbey clock at St. Albans in the first half of the fourteenth century. Of this, unfortunately, no trace remains. So it is permissible to suppose that it was an astronomical clock of the type of the Astrolabe clocks which were then not uncommon on the Continent.

Hooke's **Anchor Escapement** (1656) is illustrated by an early, though not contemporary, clock movement. A model of his **Spring Balance** wheel (1677) is still a desideration.

In the Evans Collection are a crucifix clock and two watches with associated sundials; and among later gifts are examples of the work of *James McCabe* (Mrs. Weldon); of *Richard Cole* (Rev. A. Bellman); of a **Repeating Clock Movement** (Rev. R. Ker); Duplex Watch Movement (H. Minn); and other horological items, including series of **Watch-cocks,** presented by Miss Lefroy. Upon one of the latter is chased the balloon of the Oxford aeronaut *James Sadler, c.* 1810.

Sir S. Morland's Schedule for New Pumps
A Broadside.

A small **fire engine** used in Christ Church, perhaps in the eighteenth century, and disposed of by that House many years ago. It is the only example now extant of the type of small, portable engine provided in case of fire by the more provident Colleges in Oxford in the eighteenth century. A large engine of the same period may still be seen in the Cloisters of New College.

Edison Phonograph (part of) (Conrad Cooke Collection) with a sound record on tinfoil made upon it, given by Mr. H. A. Hinton, H.M. Inspector of Schools.

Tainter Graphophone on table-stand with pedal. *Henry Edwards* patent.

Railway or Tram Road from Stratford-on-Avon to Moreton-in-the-Marsh 1820; opened 1826, taken up 1918. A rail, two chairs and stone sleepers. This was the first railway to reach Oxfordshire from the outside world, and it was used to carry heavy canal-borne traffic.

Deep-sea Water-bottle for bringing up samples of water from the bottom of the sea. Dr. Daubeny.

Air Pump

In the next compartment is a **Double Barrelled Air Pump** also by Edward Nairne of London, with a quantity of spare glass receivers and other accessory apparatus for demonstrating what Boyle termed 'the spring of the air'. The small 3-inch Magdeburg Hemispheres recall the classic experiment of 1654, when sixteen horses could not drag the exhausted vessels apart.

This type of air pump, regarded as the inven-

tion of F. Hawksbee, shows a very marked improvement on the somewhat clumsy pump of Robert Boyle and Hooke, which was modelled on that of Otto von Guericke of Magdeburg (1654). Boyle's '*Aire-Pump*; or an Engine to exhaust the Air out of any vessel fitly applied', was certainly in the Cabinet of the Royal Society in 1681, but it is so no longer; and we do not know of any example of the *Machina Boyliana* (*c.* 1658) now in existence. One of the most important of Oxford inventions can therefore only be illustrated by a drawing, and perhaps later on by a model. With his instrument Boyle performed the classical experiments on the weight, the pressure, and the elasticity of the air, and on the part it plays in respiration and in acoustics. And as a result he formulated the Law which is now associated with his name, that the *pressure exercised by a given quantity of gas is proportional to its density.*

An early reference to the air pump occurs in the Minutes of the meeting of the Royal Society for 2 January, 1660–1, when Mr. Boyle was requested to bring in his 'cylinder', and to show at his best convenience his experiment of the air. On 13 February the Danish Minister was 'entertained with experiments' on the air pump. Improvements followed, but apparently not as rapidly as the Society desired, for on 27 March Mr. Boyle was 'desired to hasten his intended alteration of his air-pump'. Whether or not he effected the alteration, we do not know; but on 15 May he absolved himself of further responsibility by presenting the Society with his engine, which afterwards became a central attraction at their gatherings. On 12 February, 1661–2 Dr. Wren proposed to try a watch in Mr. Boyle's engine, and it was possible that the discovery that sound requires

a material medium for its transmission was then made.

No scientific instrument has had greater honour paid to it than the Machina Pneumatica of Boyle, for though lost to earth it has been translated to the heavens, where in the southern hemisphere

micat inter omnes
Boylium sidus, velut inter ignes
Luna minores.

As the air pump of Robert Boyle is recalled by Nairne's interpretation of Hawksbee's model, so his important *Hydrostatical Paradoxes made out of new Experiments* (1664–6) are recalled by the **Hydrostatick Balance** found in the Library of St. John's College. Perfect in all but the supporting standard, it is provided with the disc-shaped counterpoises, glass weight, and bucket that were designed by F. Hawksbee of 'Vine Office Court, off Fleet Street', for determining specific gravities of solids and liquids. The instrument may be dated *c.* 1710.

The Barometer. Boyle is stated to have been the first man to give the name 'Barometer' to instruments that had been previously known as 'glass-canes' filled with mercury. As early as 1659 or 1660, if not before, he 'happen'd to discover the use of it in relation to the Weather'. A more epoch-making discovery can hardly be conceived, and it has the special local interest of having been made in Oxford, and confirmed by simultaneous observations made with two instruments, one at Oxford and the other some four miles off at Stanton St. John.

We owe the exhibition of a barometer with a bent tube to Captain Spencer Churchill. The invention has been attributed to Sir Samuel Morland.

Although no really early **Barometer** appears to have survived in Oxford, it is hoped that the wall-case containing later instruments may serve to recall to mind that it was at Oxford and at Stanton St. John that Robert Boyle in 1665 caused simultaneous observations to be made with barometers at both stations with the view of forecasting the weather from the difference of their readings.

An early type of barometer used in the Old Ashmolean was the invention of Professor Caswell, described in the *Phil. Trans.* No. 290, but it has been removed long since. The finest early barometers on public exhibition are perhaps those by Hooke's contemporary *T. Tompion,* in Hampton Court Palace. In Oxford we had nothing older than one or two instruments by *Bird,* and Dr. Daubeny's Travelling Barometer which accompanied him on his travels in the Auvergne and up Vesuvius and Etna, until Mr. C. F. Bell presented the **Cistern of Barometer,** patented 1695 by *Daniel Quare.*

Wheel Barometer by *Schmalcalder,* formerly owned by Professor J. O. Westwood, F.R.S., represents Hooke's invention of 1666.

Standard Barometer by *Stampa & Co., fecit London,* presented by F. Barney, late janitor to the Collection.

Mountain Barometers used by Dr. Daubeny *c.* 1820–40.

Marine Barometer by *Bate, London.*

Adie's Patent Sympiezometer.

Thermometers

Original **Maximum and Minimum Thermometer** by *Sixe* 1794, from the Old Ashmolean Laboratory.

Metallic Thermometer by *Bréguet,* from ditto.

Long Range Thermometer by *Dudley Adams* (temp. Geo. III). Purchased at L. Evans, sale.

Clinical Thermometer with bent stem. (Sir D'Arcy Power.)

Electrical Machines

Globe machines came before Plate machines, which were the invention of Jesse Ramsden, *c.* 1770. They recall the amusing experiments of an earlier day, when the bodies of several electricians were employed. The first would excite the globe with his dry hand, the second, hung from the ceiling by silken cords, served as a prime conductor, and yet a third would act as a corpus vile to receive spark discharges.

Vertical Spherical Frictional Electrical Machine. By Nairne, London, *c.* 1760. A 9-inch glass globe is cemented to a vertical axis, which can be rotated by a crank handle, operating a cog-wheel and tangent-screw gear contained in a brass box. The rubber is adjustable by means of a screw and a spring. The prime conductor, insulated by a glass pillar, was provided with a Lane's discharging electrometer.

Later additions include Priestley's original **Thunder House** for demonstrating use of lightning conductors, and a silver medal.

Vyle's patent **Lightning Conductor,** removed from the Sheldonian Theatre, was replaced by a copper band in 1928.

Dynamo, Conrad Cooke, by *Watkins & Hill.*

Gramme Dynamo, presented by Lily Warren, Duchess of Marlborough, on the decease of George, 8th Duke of Marlborough, 9 November, 1892, by *Bréguet.*

OPTICAL INSTRUMENTS

Burning Glasses

A piece of early old Ashmolean Chemical Apparatus is the **Large Burning Glass,** of 16 inches in diameter. There is nothing to show who was the maker of this large lens, but such burning glasses—12 and 16 inches in diameter—were used by Joseph Priestley, *c.* 1770, who obtained them from Samuel Parker (*d.* 1817), a London optician.

The use of lenses for making fire was of great antiquity in the Eastern Mediterranean. A passage in the *Clouds* of Aristophanes, Act 2, which was performed in 424 B.C., makes distinct reference to burning glasses. Strepsiades remarks to Socrates that he has no doubt seen in the hands of the druggists the fine transparent stone with which they light the fire. Socrates asks him if it is glass that he speaks of, and Strepsiades, replying in the affirmative, adds that by holding this stone to the fire, he could, at a distance, melt any writing of assignation (such writings were traced on wax), and thus free himself from his debts.

In our own country the practice of kindling the new fire on Easter Even by a burning glass was not uncommon in the Middle Ages. An entry to that effect occurs in the Inventory of the Vestry of Westminster Abbey, in 1388, 'unus lapis de berillo rotundus pro novo igne in vigilia Pasche a sole capiendo.' So too at York, 'ignis de berillo vel de silice exceptus'.

Large burning glasses were greatly treasured by the early scientists, who occasionally mention them in their wills. Sir Kenelm Digby, for instance, left his burning glass to the Earl of Bristol in 1665. Dr. Wilkins of Wadham College presented two to the Royal Society in November 1663. One was in a brass, the other in a wooden, frame.

Optical Apparatus

Many optical instruments are mentioned among the Orrery and R A.S. Collections pp. 22 and 118.

The Oriel Collection also includes a Microscope by Nairne, an Octant, two Sextants and a **Sky Optick**, *c.* 1750–1800, with a convex lens mounted in ball of lignum vitae.

Lenses mounted in this manner were fixed in a window-shutter and were used to throw images upon the screen in a Camera Obscura.

Magic Lantern and Camera Obscura

References to the use of lenses for projecting images upon a screen are to be found in all early works on Optics, but no very ancient instrument that was used for such a purpose is now extant. We have, however, in the Orrery Collection, a small **Camera Obscura** of about A.D. 1700 and the fitting for a **Sky-Optic**—a lens in a ball and socket joint, which when fitted to the shutter of a darkened room threw a beam of light on to the back wall.

The Magic Lantern proper was described by Kircher in 1671. The earliest type that was widely used was known as a **Phantasmagoria,** and the specimen in the Old Ashmolean is reputed to have been the first to have been used in the Channel Islands in Jersey.

Photographic Cameras, etc.

Portrait Lens formerly used by *Daguerre* (Conrad Cooke).

Wet-plate Cameras by *J. Robinson* used by J. Barclay Thompson of Christ Church (H. Minn); by *Ch. Chevallier* (Alfred Robinson); and one used by Professor Daubeny.

Sutton's **Panoramic Camera** with globular lens which was filled with water, 1860 (H. Minn).

Wet-plate Photographic outfit used by Charles Dodgson ('Lewis Carroll') of Christ Church.

Aplanatic Lens by *Grubb*, 1857.

French **Petzval Lens**, 1859.

Rapid Symmetrical by *Ross*, 1875 (H. Minn).
Triple Achromatic Lens by *Dallmeyer*, 1861 (R. T. Lattey).

German Lens by *Rodenstock, Münchên* with iris diaphragm and **Correction** for *Bildaufr*-[*ahme*] *und Mattsch*[*eibe*] (E. M. Nelson).

Photographic Prints

As occasionally happens in the history of inventions, the solution to the problem of the production of permanent photographs was reached simultaneously by independent investigators. In the case of Photography the *annus mirabilis* was 1839, when Daguerre in Paris, Fox-Talbot and Sir John Herschel all published their contributions to the art. Dr. Daubeny, as Aldrichian Professor of Chemistry, illustrated his chemical lectures in the Old Ashmolean with two Daguerreotypes taken by Daguerre in Paris and with two Calotypes taken by Fox Talbot in the Oxford Botanic Garden in 1842 by the new process invented in 1839; and now Miss Herschel and Lady Lubbock have presented to the Collection some of the very first photographic

prints fixed by their father, Sir John Herschel, by his newly discovered method of fixing silver prints by hyposulphite of soda. A photograph of the page in his diary is exhibited alongside his nature print of a skeleton oak-leaf with the letter J inked upon it.

A fine **'tin plate'** photograph of an Indian Chief was taken when Sir Henry Acland visited Canada with Edward VII when Prince of Wales, given by Miss Sarah Acland, a most skilful photographer, winner of prize medals, presented by Mr. Henry D. Acland, and now in the Collection. She was a pioneer in working newly discovered processes in colour photography.

A series of dated photographic transparencies illustrate the most important methods in vogue, *c.* 1850–70. Note the oldest of all, a beautifully clear albumen transparency; then the **collodion** slides (H. Minn).

The dated **colour photographs** include examples of the processes of *Sanger-Shepherd, Thomas Paget, Autochrome, Agfa,* prepared and presented by Messrs. Minn, A. Thornton, S. Casson, H. Taverner, &c.

The beautiful art of the **Lantern Slide-maker** is well illustrated by an exquisitely painted series by Mr. *H. M. J. Underhill* of Oxford, presented by his sister, who also gave the exhibition frame in which they are displayed: also by the coloured slides of insects by Mr. *Eltringham*

Instantaneous Photography

The historic photograph by *Marsh Bros.* of Henley, of the Flying Dutchman running at 60 miles an hour through Twyford Station on the old broad-gauge rails, on August 3, 1880. It was the

first instantaneous photograph to be awarded the Medal of the Royal Photographic Society.

In reply to a letter from the Curator to *The Times,* Mr. Falconer Madan has presented a copy of the original printed label.

Cinematography

The **Muybridge Medal** commemorates the centenary of Edward James Muybridge (1830–1902), inventor of the Zoopraxiscope for reconstructing the correct attitudes of men and animals in motion. It is believed to be one of a small number struck for presentation as a prize to the boys of the Grammar School at Kingston, where Muybridge was born and received his early education. Under the auspices of Sir Henry Acland, Muybridge lectured in Oxford, and his work on Zoopraxography undoubtedly contributed to the invention of the Cinematograph. (Mr. H. Minn.)

The series of **Lantern Slides** comprise the early painted caricatures used with the Phantasmagoria lantern; slipping comic slides; Moving Astronomical slides; Kaleidoscopic slides.

Motion-figure Slides, representing a stage in the evolution of the Cinematograph.

Photographic slides.

TELESCOPES

The Orrery telescopes, &c., are in the Orrery Case at the East end of the Room.

The importance of carefully preserving original pieces of scientific apparatus is well illustrated by the history of the Telescope. Unless a claim to originality of invention is supported by the confirmatory evidence of the instrument itself, or by so full a specification as to make it unequivocal, an early inventor may not receive the credit he deserves. Purely literary allusions to an invention are apt to be either passed over, or treated as fabulous.

Thus it has come about that the invention of the telescope has been attributed to many: to GALILEO, who should rather be held to have advertised its utility by his astronomical discoveries; to the DUTCH MAKERS OF SPECTACLES, who appear to have been the first to put it as a commercial article upon the market, thus providing contemporary savants with a handy and complete instrument, the optical tube; to the Elizabethan writer and philosopher, LEONARD DIGGES, of Oxford, who, as will be seen, must have constructed a reflecting telescope, and to the still earlier

'Doctor Mirabilis', Roger Bacon. But let them speak for themselves.

The earliest of all, Roger Bacon, who died about 1294, wrote—

'Glasses or diaphanous bodies may be so formed that the most remote objects may appear just at hand, and the contrary, so that we may read the smallest letters at an incredible distance, and may number things, though never so small, and may make the stars also appear as near as we please.'

It is inconceivable that man should have arrived at such a thought without some practical experience, or without information of the practical experience of others. We have no evidence that Bacon had this practical experience: but there is none to show that he had not. He may have been repeating what was common knowledge among the initiates of his time, but until an earlier authority is forthcoming, the name of Roger Bacon must remain associated with the first notice of the telescope, for certainly his writings have been a source of inspiration to later inventors.

About a century later, the specific name by which telescopes were commonly known is used by Chaucer, *c.* 1386, in a sense that implies that the instruments referred to were well known in his time. The 'queynte mirours and . . . perspectyues' of the *Squire's Tale* may well have been the 'perspective glasses' of a later day.

The tradition of Roger Bacon's telescope was never wholly lost; about the middle of the sixteenth century Robert Recorde reported—

'Great talke there is of a glasse that he made in Oxforde in whiche men myght see thynges that wer doon in other places, and that was iudged to bee done by power of evill spirites. But I knowe the reason of it to bee

good and naturall, and to be wrought by Geometrie (sythe perspective is a parte of it).'[1]

There is no reason why any one, into whose hands an optical MS. of Bacon's might have fallen, should not have constructed a telescope for himself. And such indeed was the case about 1550, or earlier, when Leonard Digges, who had been an undergraduate at University College, had profited so greatly by studying a Baconian MS., now presumably lost, that he 'was able by *Perspective Glasses* duely scituate upon convenient *Angles* in such sorte to discover every particularitie in the countrey rounde about wheresoever the Sunne beames mighte pearse'.[2]

Digges by another instrument would even seem to have anticipated the Newtonian Reflecting Telescope by a hundred years.

'By concave and convex mirrors of circular (spherical) and parabolic forms, or by paires of them placed at due angles, and using the aid of transparent glasses which may break, or unite, the images produced by the reflection of the mirrors, there may be represented a whole region; also any part of it may be augmented, so that a small object may be discerned as plainly as if it were close to the observer, though it may be as far distant as the eye can descrie.'[3]

Leonard Digges died about 1570. Had he lived longer, he would no doubt have given his discoveries in Optics to the world and have been numbered among the greatest of the inventors that Oxford has produced.

[1] R. Recorde, Preface to the *Pathway to Knowledge, Booke of the principles of Geometrie*, 1551.

[2] Th. Digges, son of Leonard Digges, *Stratioticos*, p. 189, 1579.

[3] *Pantometria*, 1571. The exact wording varies in different editions.

His son, Thomas, reasserted his father's claim as a discoverer:

my father by his continual paynfull practises, assisted with demonstrations *Mathematicall*, was able, and sundrie times hath by proportionall Glasses duely situate in conuenient angles, not onely discouered things farre off, read letters, numbred peeces of money with the very coyne and superscription thereof, cast by some of his frends of purpose vppon Downes in open fieldes, but also seuen myles of declared what hath bin don at that instante in private places:[1]

'Marveilous are the conclusions that may be performed by glasses concave and convex, of Circulare and parabolicall formes, using for multiplication of beames sometime the aide of Glasses transparent, which by fraction should unite or dissipate the images or figures presented by the reflection of others'. . . . 'But of these conclusions I minde not here more to intreate, having at large in a volume by itselfe opened the miraculous effects of perspective glasses.'[2]

But, as in the case of Roger Bacon, the actual instruments which would have convinced the world regarding the real inventor of the telescope are not now extant.

Galileo's Telescopes

Replicas of **Galileo's telescopes** now in Florence are on exhibition with the collection by the courtesy of Professor Turner. One has a plain parchment cover, but the other cased in leather is decorated with gold stampings.

The oldest telescopes now extant in Oxford are exhibited in the Orrery Case.

[1] Facsimile of passage describing the performance of Leonard Digges's Telescope. *Pantometria*, 1571.

[2] *Pantometria*, i, chap. 21, published by Thomas Digges in 1571.

ROYAL SOCIETY'S

LETTER.

I Have (by Order of the Royal Society) ſeen and examined the Method uſed by Mr JOHN MARSHALL, for grinding Glaſſes; and find that he performs the ſaid Work with greater Eaſe and Certainty than hitherto has been practiſed; by means of an Invention which I take to be his own, and New and whereby he is enabled to make a great number of Optick-Glaſſes at one time, and all exactly alike; which having reported to the Royal Society, they were pleaſed to approve thereof, as an Invention of great uſe; and highly to deſerve Encouragement.

Lond. Jan. 18. 1693, 4.

By the Command of the Royal Society;

EDM: HALLEY.

Non-Achromatic Telescopes

½-inch Ivory-mounted 1-draw **Galilean or Perspective Glass,** *c.* 1710. The telescope with which Galileo made his great discoveries was of this type, having a concave eye-lens, as in the common modern opera-glass.

Galilean Telescopes, signed *I. Cuff London* and *C. Watkins.*

⅞-inch **Refractor of the Keplerian type,** *c.* 1700. Vellum tube stamped in gold with the name of the maker John Marshall, Lvdgate Street, London. Length, when fully extended, 9 feet. John Marshall was practising as a manufacturing optician in the Strand in 1690, and in 1693–4 he received a testimonial from Edm. Halley as President of the Royal Society.

Archimedes and Three Golden Prospects was his shop sign, for which two telescopes, like the Orrery example, served as 'supporters'. The testimonial was evidently of use to him, for as late as 1721 we find him advertising himself 'as the only Person approved of by the Royal Society for the Art of Glass-grinding'.

1⅝-inch Refractor, 1702–10. Focal length about 9 feet. The object glass, inscribed *Jac: Wilson, Londini fecit,* is mounted in a wood cell. Wilson's microscope lenses were famous, but there cannot be many telescope object-glasses signed by him now in existence. So far as we know, this one is unique.

The painted wooden tube, 3 inches square, is provided with a sliding copper cradle with trunnions for use on a tripod belonging to the 1¼-inch refractor described below. Extension,

partly by a square wooden draw-tube, partly by a round green vellum tube, which serves as a fine adjustment. This type of instrument was figured in the *Phil. Trans.* for 1667.

1¼-inch Refractor, *c.* 1700. Focal length about 7 feet 9 inches. The lenses, now missing, were mounted in brass mounts with sliding shutters at the ends of the 3-inch square mahogany tube. A sliding cradle with trunnions carried the tube on a tripod stand, but additional steadiness and support was gained by a cord attached to a brass C-hook near the eyepiece, a support necessary when the heavy micrometer was used.

A wooden bracket bearing two wooden 3-inch pulley wheels seems to have been employed by Lord Orrery for supporting the telescope.

7-foot Refractor that belonged to the greatest astronomer ever connected with Oxford, James Bradley, discoverer of the Aberration of Light in 1729, and of the Nutation of the Earth's axis, in 1741. For many years it had been stored in the Fellows' Library of the College, but there is singular appropriateness in its exhibition in the Old Ashmolean, for it was here that Bradley from 1729 onwards gave experimental lectures in Natural Philosophy as the study of Physics was then termed. He delivered three courses of lectures a year, completing his seventy-ninth course in 1760.

The **Micrometer Eyepiece** belonging to the instrument is probably one of the oldest micrometers now extant.

Gascoigne used a thread micrometer as early as 1640, but his method was so little known that even in 1717 Derham considered the facts of Gascoigne's invention worthy of a letter to

Crabtree, which was printed in the *Philosophical Transactions*. This must have been about the date of the Orrery instrument. Gascoigne's micrometer passed into Townley's hands, and he improved it by adding a double threaded screw.

At the meeting of the Royal Society for July 11, 1667, Mr. Hooke reported that D. Croune 'had received from Richard Townley esq., Mr. Gascoyne's instrument for measuring the diameter of the stars with great exactness; which instrument was afterwards shewed to the Society'.

Achromatic Telescopes

Achromatic Telescopes were first constructed as early as 1733 by a country gentleman of Essex, Mr. Chester Moor Hall; but as he was held by a court of law to have 'locked his invention in his scrutoire', patent rights were granted to the Huguenot silk weaver, John Dollond (1706–61), who had independently arrived at a similar discovery and 'had brought it forth for the benefit of mankind'.

John Dollond's son, Peter, devised the triple object glass in 1765, and ever since the optical principle of the Refracting Telescope has remained practically unchanged.

The **4-inch Achromatic Telescope,** *c.* 1770, belonging to Queen's College. By Dollond, *c.* 3 ft. 6 in. focus.

A portrait of Peter Dollond was painted by Zoffany for a picture known as 'The Lapidaries', but obviously done in the atelier of an optician. The picture is now at Windsor and we are indebted to H.M. the King for a photograph of this interesting portrait.

Reflecting Telescopes

In 1663 James Gregory proposed a 'Cata-Dioptrical Telescope', but owing to his want of skill in the polishing of specula, his own instruments did not achieve much success. One of his specula was ground by 'Rives and Cox, two Optick glass grinders of London famous in those days'.

2-inch Gregorian Reflecting Telescope, *c.* 1710. Orrery Collection, 12. This instrument is perhaps the oldest known example of the telescope invented by Dr. James Gregory and improved by Hadley. The brass mounting with a double knuckle joint is screwed horizontally into a wooden pillar stand. As originally sold, these instruments were accompanied by a small hand-auger for boring a hole in the side of a post or tree, for supporting the telescope 'when used abroad'. The brass tube, 16 in. long, has lost its original shagreen covering.

The first persons to bring Reflectors into general use are said to have been Scarlett and Hearne, the opticians; but the art was not brought to its greatest perfection before James Short in 1732, at the age of 22, began the grinding and polishing of specula. The fine example of his work belonging to the Radcliffe Trustees has been dismounted.

3-inch Gregorian by *James Short* on equatorial mounting. Lent by R. T. Gunther, with portrait of maker.

There are 4-inch Gregorian Reflectors both at Queen's and Magdalen. Several similar instruments made by Dollond were provided with a special fitting for measuring the apparent diameter of the sun. The apparatus was the

invention of Servington Savery in 1743, who called it a micrometer. It is, however, better styled by Bonguer's name of héliomètre.

6-inch Reflector made by *William Herschel.* In the words of the Astronomer Royal, it is an example of one of the tools made with his own hand, which the 'Father of Stellar Astronomy employed to demonstrate to us the nature and vast extent of the Sidereal System'. It was formerly owned by Archdeacon Nathaniel Jennings, F.R.A.S., of Regent's Park, presented by the late Dr. Herbert N. Evans of Exeter College. Herschel's discovery of the planet Uranus on the Georgium Sidus is commemorated by a **Medal of George III,** with a figure of the **Georgium Sidus** on the reverse which can be seen by reflection in a mirror of Herschel's own polishing.

Terrestrial Telescope by *Merz and Fraunhofer* selected for use of Prussian Officers during the Franco-German War of 1870. Presented by William, King of Prussia, to Sir H. Acland, and by his son Frank Acland to Oxford.

Savery's Heliometer, *c.* 1755, probably by P. Dollond. Bequeathed by Prof. N. Story-Maskelyne to the Mineralogical Department.

Royal Astronomical Society's Collection, *c.* 1800–70

The Telescopes include a **4½-inch Gregorian Reflector** with six-inch altitude and azimuth circles and two eyepieces by *James Short* (86), on an altazimuth stand. A **14½-inch Gregorian Speculum,** perhaps by the same excellent maker, for a 7-foot telescope (9), formerly in the possession of

Mr. Shearman. A **Galilean** telescope with $1\frac{5}{8}$-inch object-glass of rock crystal (64) from the Sheepshanks Collection. Also an early **non-achromatic** telescope by *Samuel Scatliffe* of London (83).

The principal MEASURING INSTRUMENTS of precision comprise five Transit instruments, the Fuller Theodolite, and a number of Reflecting Circles and Sextants.

The **4-foot Beaufoy Transit** (4) was originally made by *Cary* of the Strand for Colonel Mark Beaufoy (*d.* 1827) who bequeathed it to his son Lieutenant George Beaufoy, by whom it was presented, together with an altazimuth circle and two clocks, to the Society by letter, dated Bushy Heath, 5 June 1827. It was on loan to the Observatory at Kingston, Canada, from 1876 to 1903.

A **45-inch Transit** (34), formerly a part of the Sheepshanks Collection.

A **30-inch Transit** by *Simms* (27).

A **$2\frac{3}{4}$-inch Transit,** with collimator and stand (138).

A **$2\frac{1}{2}$-inch Transit** by *Reade* (21).

The **Variation Transit** by *Dollond* (10) is a small but very carefully fitted instrument with a compass needle 5 inches in length. The telescope, $7\frac{3}{4}$ inches long and $1\frac{1}{8}$ inches in diameter, is complete with the exception of one eyepiece and some smaller fittings It was bequeathed to the R.A.S. by Mr Shearman; cf. *Monthly Notices,* xxxvi, p. 134, 1876.

With the Sheepshanks Collection is also a **Level Collimator** (41), with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

The **Fuller Repeating Theodolite** (4), built by *T. Jones* of Charing Cross, is provided with a horizontal circle of 20 inches in diameter, graduated on silver, reading off to seconds by three micrometer microscopes, which are attached to a frame concentric with the circle and on the same axis; also with a 30-inch transit telescope with levels and a divided circle as in the great Theodolite of the Trigonometrical Survey. It was presented to the R.A S. by J. Fuller, and from 1869 to 1876 was on loan to the Sydney Observatory. Two letters accompanying the instrument indicate that in 1885 and 1888 its telescope, described as a 'transit', was in the hands of Mr. *James Simms* for overhaul for the Rev. J. E. Cross, F.R.A.S., Vicar of Appleby, near Doncaster.

The **Beaufoy Circle** (3) by *Cary*. This once fine instrument is in a sad state of dilapidation. The pillars and main framework of the stand are complete, but the reading microscopes and fittings are broken, lost, or gone to decay. The altitude circle of about 26 inches in diameter and the azimuth circle of 24½ inches, with their respective cones and pivots, appear to be good. The spider lines in the telescope are still in their places, but the pinion at the eye end is broken, and part of the cap is lost.

The **Lewis Evans Circle** (17). A 2-foot altitude circle divided on gold by *Troughton*, mounted on a massive rounded stone base and conical brass pillars. The object-glass is 2 inches in diameter and 30 inches focal length; and the accessory apparatus includes two direct and two diagonal eyepieces, and three levels.

This fine instrument, hitherto generally known as the *Lee Circle*, was purchased specially for pre-

sentation to the R.A.S. by Dr. John Lee. But as it was actually used for many years by its first owner, the Rev. Lewis Evans, F.R.S., and has now rejoined some of this astronomer's other instruments presented to Oxford by his grandson, Dr. Lewis Evans, it may more appropriately be named the **L.E. Circle** than the Lee Circle.

The **Sharpe Reflecting Circle** (18). A 10-inch reflecting circle by *Troughton and Simms*, of the usual type with three verniers; complete, with the exception of a small reading lens.

The **Owen Portable Circles** (2 and 2*a*) are Double Reflecting Circles made by *Jones* of Charing Cross under the direction of Captain W. F. Owen, R.N., and presented by the latter to the R.A.S.

In this ingenious instrument there are two reflecting circles parallel to one another. Each is divided on silver and is read by four indices on each limb; the verniers reading to 20 seconds of arc. These several readings Captain Owen reduced to one by a table exhibiting all the corresponding readings at every degree for 140° on each side of zero.

When each circle is used independently the instrument differs but little from Troughton's reflecting circle, but when the two are used together they are capable of measuring the two angles subtended by three objects in the same plane at the same instant, which is a problem of extensive utility in sea-surveying. This is done by bringing the right- and left-hand objects in contact with the middle one. If the middle object is wanting, the contact of the other two can be made. Such an arrangement also admits of small angles being measured on many parts of the divided scales, and thus minimizes the errors of division.

The instrument also measures altitudes in low latitudes, when they are beyond the limits of the sextant or circle; also the angular distance between opposite horizons, and the value of the apparent dip thus obtained, which Capt. Owen observed to differ considerably from that in the tables, owing to the effects of terrestrial refraction. They were used by Mr. Burn in 1860 and by Mr. Lecky in 1877.

Of a smaller size are the five **Reflecting and Repeating Circles,** three by *Troughton and Simms* (42, 44, 56) and two by the Parisian makers *Lenoir* (45) and *Jecker,* with vernier reading to 15 seconds (46), all of which formed part of a series of representative instruments.

Among others who have benefited thereby from 1860 onwards were Messrs. Lassell, Wheatstone, and Dayman, and in 1869 Charles Pritchard, later Savilian Professor in Oxford, but another instrument, a **Varley Stand** for a Telescope, taken out by him is not now extant.

The Sextants include a **Quadruple Reflecting Sextant** by *T. Jones* (112); a Box Sextant by *Troughton and Simms* (105) and **George's Double Box Sextant** made by *Cary* (131), with two **Artificial Horizons** (58, 59), one of which is by *Dollond.* The highly ingenious Quadruple Sextant was devised by Captain W. F. Owen, R.N., for measuring the angles between three objects at the same time. It was presented to the R.A.S. by the designer. (Cf. *Monthly Notices,* ii, p. 195.)

A 10-inch **Pillar Sextant** by *Troughton, London,* (130).

Double Image Micrometer (85).

Optical Apparatus

Spectroscopes :

A **six-prism Spectroscope** by *Browning* (120).

Pocket Spectroscope by *Browning* (111).

Two **five-prism direct vision Spectroscopes** by *Browning* (76).

Spectroscope (79), formerly on loan to the Solar Eclipse Committee of the British Association in 1870 and to Mr. Norman Lockyer.

Diffraction Gratings (119) by Professor *W. A. Rogers* of Cambridge, Mass., given to the R.A.S. by H. Chaney in 1884.

Three Polarimeters (72), for a time lent by the R.A.S. to Mr. Ranyard and to the British Association Eclipse Committee of 1873.

Universal Astronomical Ring Dials of 6-inch, 4-inch, and $2\frac{3}{4}$-inch diameter (143, 112, 144), and a small portable sundial by *Casella* (103).

Armillary Sphere (129) as improved by *Slater*.

Cometarium (115), signed *John Taylor jnr.* 1828, *R. Adie fecit Liverpool* 1835. Originally the property of Sir James South and presented in April 1880 to the R.A.S. by Mrs. Hannah Jackson Quilt. The model is provided with five interchangeable plates for as many Cometary Orbits, three being fully inscribed.

Astronomical Watch Case for reading astronomical time from the watch dial of an ordinary watch, devised and autographed by Professor *Temple Chevallier*.

Globe showing the precession of the equinoxes (26).

The additions to our series of DRAWING INSTRUMENTS comprise a Pantograph (62) by *Cox* of London, a 2-foot Protractor (92), *T. Jones's* Circular Protractor (61), and a Beam Compass (93) invented by *W. and A. Smith* and sold by *M. H. and I. W. Allen of Dame Street, Dublin*.

THE MICROSCOPE

By far the most important instance of an invention resulting in an epoch-making discovery, can be associated with the name of Robert Hooke of Christ Church. The establishment of the Evans Collection in the Old Ashmolean Museum now affords an opportunity of doing honour to the inventor at his own University after the lapse of some two hundred and fifty years.

Although less famous than the story of Galileo and the Telescope, the achievement of Hooke and the Microscope was greater in every way. Galileo merely used some one else's telescope, pointed it in the direction of Jupiter's Satellites, and made his discovery. By his mechanical genius Hooke invented an entirely new method of supporting his microscope, a method that has been universally adopted since. He then pointed it at a specially prepared section of vegetable tissue, and, for the first time in the history of mankind, saw *cells*—observed, in fact, that the particular tissue, at which he was looking, consists of nothing but cells. And this was the first start of what is perhaps the most important generalization ever made with regard to the structure of living things.

On April 8, 1663, at a meeting of the Royal Society, Hooke had been ordered to have ready against the next Meeting 'the microscopical appearance of the little fishes in vinegar'. He did something far greater in the History of Science. He described his Instrument and his Discovery to the Royal Society on April 15, 1663, and afterwards published both in *Micrographia* in 1667.

The whole matter is of such basic importance

that we make no apology for printing his procedure and conclusions *in extenso*.

'I took a good clear piece of Cork, and with a Pen-knife sharpen'd as keen as a Razor, I cut a piece of it off, and thereby left the surface of it exceeding smooth, then examining it very diligently with a Microscope, me thought I could perceive it to appear a little porous; but I could not so plainly distinguish them, as to be sure that they were pores, much less what Figure they were of: But judging from the lightness and yielding quality of the Cork, that certainly the texture could not be so curious, but that possibly, if I could use some further diligence, I might find it to be discernable with a Microscope, I with the same sharp Pen-knife, cut off from the former smooth surface an exceeding thin piece of it,[1] and placing it on a black object Plate, because it was it self a white body, and casting the light on it with a deep plano-convex Glass, I could exceeding plainly perceive it to be all perforated and porous, much like a Honey-comb, but that the pores of it were not regular; yet it was not unlike a Honey-comb in these particulars.

'First, in that it had a very little solid substance, in comparison of the empty cavity that was contain'd between.

'Next, in that these pores, or cells, were not very deep, but consisted of a great many little Boxes, separated out of one continued long pore, by certain Diaphragms, as is visible by the Figure B, which represents a sight of those pores split the long-ways.

'I no sooner discern'd these (which were indeed

[1] Perhaps the first occasion on which a microscopic *section* was cut.

the first microscopical pores I ever saw, and perhaps, that were ever seen, for I had not met with any Writer or Person, that had made any mention of them before this) but me thought I had with the discovery of them, presently hinted to me the true and intelligible reason of all the Phænomena of Cork.

'Nor is this kind of Texture peculiar to Cork onely; for upon examination with my Microscope, I have found that the pith of an Elder, or almost any other Tree, the inner pulp or pith of the Cany hollow stalks of several other Vegetables: as of Fennel, Carrets, Daucus, Bur-docks, Teasels, Fearn, some kinds of Reeds, &c. have much such a kind of Schematisme, as I have lately shewn that of Cork, save onely that here the pores are rang'd the long-ways, or the same ways with the length of the Cane, whereas in Cork they are transverse.

'But though I could not with my Microscope, nor with my breath, nor any other way I have yet try'd, discover a passage out of one of those cavities into another, yet I cannot thence conclude, that therefore there are none such, by which the *Succus nutritius,* or appropriate juices of Vegetables, may pass through them; for, in several of those Vegetables, whil'st green, I have with my Microscope, plainly enough discover'd these Cells or Poles fill'd with juices, and by degrees sweating them out: as I have also observed in green Wood all those long Microscopical pores which appear in Charcoal perfectly empty of any thing but Air. . . . though, me thinks, it seems very probable, that Nature has in these passages, as well as in those of Animal bodies, very many appropriated Instruments and contrivances, whereby to bring her designs and end to pass, which 'tis not improbable, but that

some diligent Observer, if help'd with better Microscopes, may in time detect.'

About 1886 an exact replica of Hooke's Microscope was made under the direction of Mayall and Sir Frank Crisp, and this, at the Crisp sale in 1925, was purchased for the Oxford collection.

The Hooke Microscope. The invention of Robert Hooke of Christ Church consisted in the mounting of the body-tube and screw-collar of the instrument upon a pillar, with a ball-and-socket movement so as to render the tube inclinable. His arrangements for illumination with a globe and lens condenser were also superior to anything previously described. Too much may be made of the comparison, but whereas the fame of Galileo's microscopy rests on his having 'invented an *occhiale* which magnifies . . . so that one sees a fly as large as a hen', Hooke's invention gave us the Cell Theory.

Marshall's Microscope for viewing the Circulation of the Blood, 1693. No. 8 in the Orrery Collection. This microscope is of the very greatest importance from the standpoint of the history of the instrument, on account of the extreme rarity of models of this period; and the historic value of this particular instrument is all the greater because it has been shut up in a cupboard with the rest of the Orrery apparatus since 1720. It is therefore likely to be in its original state.

There are both coarse and fine adjustments; it shows several advances on the Hooke model.

The ball-and-socket joint borrowed from Hooke is applied between the pillar and the base: thus the movements of inclination affect both object and body-tube alike, as in all modern instruments.

The condensing lens on a jointed arm was the first application of such adjustments to the condenser.

The later types of microscopes are poorly represented in Oxford. No local example of the Culpeper-Scarlet tripod model of 1738 was extant, before two derivatives of that type came with the Evans collection. Oxford is richer in microscopes of the later Cuff model, with its four-cornered stage and improved fine adjustment. Of this there are examples by *Dollond* and by *G. Adams* in the Christ Church collection, and by *Nairne* in the Oriel collection.

A former possession of the Ashmolean Museum, a *Pritchard* Jewel Microscope, engraved 'Ash. Mus. Oxford' has, thanks to the public spirit of the Delegates of the University Museum, found its way back to its ancient home. A recent acquisition is also a *Pillischer* microscope, presented by Dr. A. G. Gibson. It is of value as a record of the great work of Sir Henry Acland in introducing the study of Histology and Microscopic Anatomy into Christ Church, and so into Oxford.

THE CRISP AND NELSON COLLECTIONS OF MICROSCOPES

In the concluding paragraph of the first edition of this work the hope was expressed that some of the historic microscopes from the fine Collection of Sir Frank Crisp may eventually find their way back to the county with which he was so long and so pleasurably associated.

Thanks to a benefaction from Viscount Hambledon given in memory of his father, the Rt. Hon. W. H. D. Smith of New College, a few examples from this Collection have come to Oxford, including the Hooke model and a Cuff instrument

from the Royal Observatory at Kew. The most noteworthy instrument in the Collection is the great silver microscope of George III by *G. Adams*, given to the Lewis Evans Collection by Sir John Findlay of Balliol College. Apart from its interest as an example of silversmith's art, it admirably illustrates the advance in design made in one century after the construction of the Hooke instrument of 1665, and one century before the masterpiece of Messrs. Powell & Leland, purchased by the Radcliffe Trustees about 1870. Some of these instruments are exhibited in a case given by Lady Osler in memory of Sir William Osler, others are shown in a case purchased by a grant given by the City of London in memory of the many useful inventions of Robert Hooke of Christ Church.

Pre-achromatic Microscopes

Nobili Scroll Microscope. (Crisp Collection, No. 556.) Belonged to Professor Nobili of Bologna, Purchased of Sign. Cassano of Bologna 1886. Fine adjustment applied to stage (R. T. G.).

Culpeper Type of Double Reflecting Microscope, *c.* 1750.

Demainbray Microscope. Given by him to George III, transferred to King's College, *c.* 1850, and acquired by Sir F. Crisp (No. 577). *Dr. Demainbray invt 1756—Thos. Bureau fecit.* Dr. Demainbray was physician to George III. A unique specimen. (R. T. Gunther.)

G. F. Brander of Augsburg **Box Microscope.** Found in an attic in Jena Physical Laboratory by Mayall, December 1886. Presented to Crisp by University of Jena 1887 (No. 550). Fig. by Sprengler. (R. T. G. Collection.)

Cuff Model, formerly in George III's Collection at Kew (Crisp, No. 558.) (R. T. G.)

Cuff Model by *Nairne* 1772–3. Oriel Collection.

Benjamin Martin Pocket Reflecting Microscope with vellum tube, *c.* 1742. Sold by J. Newbery, Reading, Berks. (Crisp, No. 663.)

Benjamin Martin No. 1, *c.* 1770. Presented by Mr. E. M. Nelson.

An instrument of very great historic importance on account of the fact that the screw with which the 'pipe' is fitted has been adopted both as regards diameter and pitch as the standard 'Society's Screw' by the Royal Astronomical Society for the fitting of object glasses. As this instrument was No. 1 of a series it is therefore the doyen of microscopes in respect of this universally adopted detail.

Dellebarre Microscope. After 1777 model.

J. Ames of Bristol **Microscope** with **Cat-gut Focusing** (Crisp, No. 580). (R. T. Gunther.) J. Ames was formerly an assistant at the Polytechnic Institution.

Bancks small Model, used by Walter Crum, F.R.S. (1796–1867). Presented by Miss E. Crum.

Schiek large model from the same source.

Solar Microscopes by *Cary* and *Jones, c.* 1795.

Achromatic Microscopes

Lister-Tully Large Stand with accessory apparatus in box, 1826. Exhibited at the Science Museum as No. 1911.288. Presented by Mr. E. M. Nelson.

Charles Hatchett's **Drum Microscope.**

Powell and Lealand Large Stand. Deposited by the Radcliffe Trustees. With a $\frac{1}{50}$ O.G.

Student's Microscope by *Crouch*, used by Professor E. Ray Lankester as Jodrell Professor of Zoology at University College, London. Lankester's older instrument by Powell and Lealand is in the Wellcome Historical Medical Museum.

Dissecting Microscope, used by Professor W. C. McIntosh at St. Andrews, *c.* 1890.

Achromatic Lenses

The first achromatic lenses were said to have been made by John Dollond, the Spitalfields weaver, whose portrait at his work-bench is in Zoffany's picture of 'The Lapidaries', but the real inventor was Chester Moor Hall, who, however, did not push his patent, so it lapsed. The earliest achromatic lens in the Nelson Collection is a $1\frac{1}{2}$-inch object-glass belonging to the Lister-Tulley microscope. It may be dated 1828, and has very good corrections for so early an achromatic; it resolves 9,000 Grayson.

Next in date is the $\frac{1}{2}$-inch, made about 1832 by *A. Ross, Optician, 15 St. John's Square, Clerkenwell,* when quite in a small way of business. He derived his knowledge from J. J. Lister, the father of Lord Lister, who in 1830 had shown how aplanatic microscope lenses could be made. By taking Lister's ideas the Ross business flourished so well that by about 1837 we find that he was able to blossom out as *Andw. Ross & Co., Opticians, 33 Regent St., Piccadilly,* who made a $\frac{1}{2}$-inch now in the Collection. The 'Co.' was probably J. J. Lister, who may have financed the firm. But the association was soon terminated and Ross lenses were then merely signed *Andw. Ross, Optician, London, c.* 1840; J. J. Lister began to help Beck, who like himself had been a Quaker Wine-merchant. It is suggested that the wine trade had not been flourishing, but that there was money to be made in microscopes. Beck was not a skilled optician, but he availed himself of the services of a fellow Quaker—one Jackson by name, and a skilful worker with the lathe, who made instruments for Beck. Probably the turned pillars under Beck microscopes were due to their construction by a lathe worker.

The **Royal Microscopical Society's Standard Screw** now universally used for objectives has also had an interesting history. About 1770 Benjamin Martin adapted a pipe to the end of the body of his microscope by a screw. When he died his workshop tools were acquired by Tulley, who made the first Lister microscope with Martin's screw tackle. On Tulley's death, his foreman, James Smith, an illiterate worker, went into partnership with Beck as *Smith and Beck, 6 Coleman St., London* (O.G. $\frac{2}{3}$ inch of 1850), and in 1859 Beck established the **Universal Screw.**

List of Objectives

Andw. Ross, Optician, London, $\frac{1}{4}$ inch, *c.* 1837; 1 inch, 1840, a triple combination; $\frac{1}{12}$th, *c.* 1848, triple front and back and double middle, has resolved 90,000 Grayson, *J.R.M.S.*, 1904, p. 395; an O.G. of the same date and type as that used by Warren de la Rue in investigations on the scale of *Amathusia Horsfieldii, Trans. R.M. Soc.*, iii, p. 39.

Ross, $\frac{1}{7}$ inch, 1837–8. An exceedingly rare lens. Ross had found out that objects under cover-glasses require corrected objectives. This is the only known example of such an O.G. in which the distance between the front and back lenses is closed by pushing up the front and turning it into a bayonet catch.

Powell improved this plan by means of the screw-collar, which was adopted by Ross afterwards.

Beck employed collars graduated with divisions on the collar—also adopted by Powell and Ross.

Powell & Lealand, $\frac{1}{4}$ inch, 1842, triple front, double middle and back, Lister formula; $\frac{1}{2}$ inch, 1845, well-corrected, resolves 20,000 Grayson; $\frac{1}{12}$ inch, *c.* 1852. *J.R.M.S.*, 1904, p. 395. Lens broken July 1918.

Baker, $\frac{1}{3}$ inch–1 inch, 1850–80. A separating Lens composed of three doublets called French Buttons. Sold in large numbers to medical students from 1850 to 1880. Image very indifferent.

A. Ross, London, $\frac{1}{6}$ inch, 1854, quadruple combination, a rare example and an excellent lens; 1 inch, 1856; $\frac{1}{2}$ inch, 1856; $\frac{1}{4}$ inch, 1859.

M. Pillischer, $\frac{1}{2}$ inch, 1855; made by Wray with meaningless 'covered and uncovered' lines; $\frac{1}{4}$ inch, *c.* 1860, three doublets probably made by Kellner.

Powell & Lealand, $\frac{1}{4}$ inch before 1857, single front; $\frac{1}{2}$ inch, 1845; $\frac{1}{60}$? 1860.

Wray, London, 1½ inch and ⅔ inch before 1858; ⅕ inch, 1878, resolves *Amphipleura pellucida* with dry condenser.

Hartnack No. 7, ⅙ inch, 1860. Adapter and box are English. No lens of its quality could have been purchased in England for three times its cost.

Ross, London, $\frac{4}{10}$ inch, *c.* 1860; ⅕ inch 1872. Ross's patent water immersion, designed by Wenham; not well corrected, but resolves when used wet, the old *Amphipleura Lindheimeri* 76,500 striae to the inch.

A. Prazmowski, Paris, ¾ inch, *c.* 1865.

Nachet Paris No. 3, ⅔ inch, 1880, with quick-changing nosepiece, *v. J.R.M.S.*, 1881.

R. B. Tolles of Boston, 1½ inch, 1882. A lens of the highest quality, resolves 20,000 Grayson. R. B. Tolles, fl. 1872–†1884, invented the epithet 'homogeneous' as applied to immersion, and was one of the best American opticians.

J. H. Dallmeyer, ⅔ inch, 1885. Made for use in Lewis Wright's Micro-lantern.

Otto Himmler, Berlin, ⅐ inch, 1885. A good example of an early cheap Lens (cost 30*s.*).

Gundlach, ⅕ inch, 1886. Used at Plymouth by the late E. W. Nelson and subsequently taken by him to the Antarctic with Captain Scott's expedition of 1910–13.

C. Zeiss, 35 mm., 1895, resolves 5,000 Grayson.

R. Winkel, Göttingen, 1910. A dividing Lens, 1 inch to ½ inch.

Francis, London, 1 inch, 1914. The first 10*s* O.G.

Bausch & Lomb Optical Co., Rochester, N.Y., 4 mm., 1918. A good example of a War Lens.

The craft of object-glass making has always been restricted to a very few skilled workers. To the excellence of their work the world owes much

of its modern civilization, immunity from disease, etc., yet they are collected by few Museums.

Accessory Microscopical Apparatus

Nosepieces for rapidly changing objectives. The idea was worked out by *George Adams* in 1771 as an addition to his Universal Double Microscope, and executed in elaborate fashion for objectives on his great silver instrument.

A modern evolutionary series given by Mr. Nelson comprises Brook's straight, 1853; Powell's bent, 1857; Beck's Quadruple, 1865; Powell's Calotte, 1882.

Superstage Illuminator. Used by *Powell* in 1869 to illuminate, resolve and count the 90,000 lines to the inch on *Amphipleura pellucida* for the first time. (*M.M.J.*, i, p. 315.) The idea was re-invented by Seidentopf, and was used for Ultra-microscopic Vision.

Positive Micrometer with Rotating Stage made by *Powell* apparently for some individual worker. The invention was due to Benjamin Martin, though attributed to Fraunhofer. (R. T. G.).

Darker's Polarizing Stage Plate.

Nelson's Lamp. *J.R.M.S.*, 1884, p. 125, Fig. 25.

Stephen's Catadioptric Illuminator.

Brook's Polariscope by *Dollond*, 1827.

Powell's Superstage Illuminator.

Ramsden's Dynamometer, 1775.

Opaque Disk Revolver.

Compressors.

Lieberkühn's Dissecting Microscope Plates in wood and brass. (R. T. G.)

MEDICAL AND SURGICAL COLLECTIONS

A special descriptive Catalogue may be had on application to the Janitor.

The greater part of the Medical and Surgical instruments on exhibition have been contributed by the **Royal College of Surgeons** of London. Around this nucleus several further exhibits of local interest have been collected, including many from the **Radcliffe Infirmary,** and from the Collection of Sir Henry Acland, Regius Professor of Medicine.

Dressing and General Instruments

Figures of early types of instruments used in Mesopotamia, Egypt, and Greece are still desiderata. But Friends of the Old Ashmolean have presented a beautiful large set of a **Persian Surgeon's Instruments,** *c.* 1800, presented to Dr. Lennox Lindley of Magdalen College, when acting as physician to the Shah of Persia. Many of the tools are of interest on account of the beauty of their design, as well as for the antiquity of their type. For this the instruments of semi-civilized nations have a special value, e.g. the iron circumcision knife and Tribal marking instrument presented by Chief Obanikoro of Nigeria per Mr. A. Rumens of Lagos.

Roman Surgical Instruments in use in Pompeii before A.D. 79 are illustrated by a series

of bronze facsimiles specially selected by the donor, Sir John Findlay of Balliol College, during a visit to Naples in 1928. They include a Roman Dilator, a Catheter and various probes. The Roman scalpel had a steel blade mounted in a bronze handle.

Naval Surgeon's Large Fitted Case by *Stodart*, used by Joseph Bellot, R.N., on H.M.S. *Pegasus*, 1790.

Set used by J. Soper Streeter, M.R.C.S., presented by Rev. B. H. Streeter of Queen's College.

Pocket Set of Lancets belonging to Dr. C. Daubeny, presented by R. Gunther; six pairs presented by Mrs. Fitzsimons of Lympstone in cases. The lancets are double-edged and were used for blood-letting.

Fleams for bleeding horses.

Liston's **Artery Forceps** used by Lord Lister, for securing arteries in open wounds so that the surgeon can tie their cut ends.

Sir Wm. Fergusson's **Osteotome** and **Tracheotomy Tubes.**

Haemorrhoid Clamp by *W. Matthews.*

Sets of **Trocars** by *Coxeter & Son.* 1860. (Penrose Williams.)

Lithotomy and **Lithotrity Outfits** of end of eighteenth century.

The **Double Knives,** invented by Dr. Valentine for the cutting of thin sections, presented by Captain G. C. Damant and Mr. Cottrell S. Horser.

Phlebotomy

The ancient operation of dry **Cupping or Blood-letting** is illustrated by models of Greek (350 B.C.)

and Roman Cupping bronze vessels. Sets of **Lancets**; set of Cupping Glasses and twelve-bladed **Scarificator** by *Maw*, presented by Professor A. E. Boycott. Sixteen-bladed Scarificator by *Pepys*, presented by Mr. E. Heron-Allen; Cupping instruments with exhausting syringe; set of Artificial Leeches (*c.* 1850), &c., used by Sir Alfred Garrod, presented by Sir A. Garrod. Cupping set by *Pepys*, presented by Mr. E. Heron-Allen, F.R.S., used by Penrose Williams, Esq.

The Blood **Transfusion Tubes** of Richard Lower of Christ Church are modelled from the engraving in his book on the heart, *De Corde*, 1669, one of the classics of medicine, recently translated into English by Dr. Franklin of Oriel.

Trepanning Sets

Operations for the relief of headache or the release of spirits from the brain were performed in the Stone Age, and a picture showing second Iron Age practice is exhibited. The Bronze **Trepan** from Mesopotamia, with a centre spike shows that even the modern form of instrument is 4,000 years old.

Trepanning Set by *Bognor of Strasbourg*, used by the French 'Hôpitaux Ambulants' probably during the Napoleonic wars. Given by Sir John Findlay. The operation is illustrated by a cranium that was drilled in $1\frac{1}{2}$ minutes by one of these circular saws and centre pin.

Samuel Forte's case of **Trepanning Instruments**, presented by C. S. Forte.

Dentistry

Tooth-key by *Weiss*, given by Dr. B. Waring Taylor of Islip.

Miniature **Dentist Set** finely fitted in agate handles.

Sundry Dental Instruments made by *Long* of Oxford; **Forceps** by *Weiss*.

Apparatus for Restoration of the Apparently Drowned

The University standard set made to the specification of the Royal Humane Society, and made by *Evans*, has been deposited by the Senior Proctor. It includes a scientifically made pair of bellows and various nozzles for forcing air with, or without, tobacco smoke into the nose, trachea, or rectum of the patient.

A more perfect set (*c.* 1810) has been presented by Professor Arthur Thomson. A set by *Pepys* in the Museum of the Royal College of Surgeons has also a copy of the original instructions for use.

Miscellaneous

Pulse-glass. A 25-second Sand-glass in wooden case, used by the noted Dr. I. Lettsom, Physician to George III. Presented by Mr. E. Milnes Nelson, F.R.M.S.

Clinical Thermometer. Early form with bent tube, given by Sir D'Arcy Power. They were first used as novelties in the wards of hospitals about 1866.

The series of **Spectacles** is in a cabinet.

Liebreich's Ophthalmoscope Case (Sir H. Acland).

Galezowski's Ophthalmoscope by *Robert* and *Colin á Paris* (Sir H. Acland).

Marey's Sphygmograph by *Bréguet*.

Apparatus for Preparing, Storing, and Giving Medicines

Pharmacy Jar excavated in Oxford. Presented by Mr. A. B. Emden. Stoppered **Bottle** for Aq. Cochleariae.

Octagonal **Pill Slab** painted with Coat of Arms and supporters of the Apothecaries' Company. L. Evans's sale.

Rolling-board for Pill-making, eighteenth century. Travelling **Medicine Chest** by Messrs. *Hitchcock & Sons,* Chemists to H.R.H. Prince of Wales, *108 High Street, Oxford,* used by Sir Henry Acland, Regius Professor of Medicine, presented by H. D. Acland with original contents. The largest bottle is nearly full of stomachic powder 'according to the formula of the late Professor Gregory of Edinburgh '.

Gibson's Pewter **Spoon** for the administration of unpleasant medicines. Presented by Dr. Birch of Dorchester.

Injection Syringes, acquired at the sale of Professor O. Westwood's effects.

'Dr James's Fever Powder, prepared by *R. James* and sold by *F. Newbery* (signed). Price *2s. 6d.* a Packet.' Sealed with a device of a snake on a bush *By the King's Patent.* Original and unopened packet presented by Mr. H. N. Savill, author of letter to *The Times,* 1929. Dr. James of St. John's College acquired notoriety when his powder was stated to have killed the poet, Oliver Goldsmith.

Spikenard of the Ancients, prepared by Charles Hatchett, F.R.S.

CHEMISTRY

The principal exhibit in the Old Ashmolean is the old *Laboratory* in the basement, reached by a double flight of stairs from the north gate on the Broad Street. When the Duke of York opened it in 1685 it was 'the most beautiful and useful in the world, furnished with all sorts of furnaces and all other necessary materials'. It was handed over to the Bodleian for use as a book-store about 1890, and is now packed with many tons of books, while its historic *Library* and 'Ashmolean' *Scientific Apparatus* is being stored elsewhere, partly in another building, partly in London, partly by the Botanic Garden. If these Ashmolean Collections, and Chemical Library could once again be assembled in the old Chemical Laboratory much of unique historic importance would be saved, which now is on the road to being lost.

It is a pity because the apparatus has been offered to the University by the present owners, the President and Fellows of Magdalen College, but the room that is necessary for its safe custody and intelligible display is occupied by books of no special association value.

The original Furnace Flues may still be seen behind the book stacks in the basement.

The early Ashmolean operator, Christopher White, appear to have eked out a precarious livelihood by the sale of chemical preparations, and to have assisted the Readers of Chemistry in

their lectures. Among the more eminent persons trained here were Dr. WALL, the founder of the Worcester China factory; JAMES SADLER the father of British Aeronautics and ardent promoter of Gas-works; WILLIAM HIGGINS, the discoverer of the principle of Multiple Proportion in Chemical Combinations; and, finally, Professor C. G. B. DAUBENY, one of the founders of the British Association, famous for his researches on Volcanoes, and on the Growth of Plants.

PRODUCTION AND APPLICATION OF HEAT

French 'Fourneau à revérbère', *c.* 1818, known in Germany as Becher's Furnace.

Cooper's Tube Furnace for Analysis of Organic Bodies. Combustions in glass tubes wrapped round with copper foil, *c.* 1828, Berlin Porcelain tube for use in ditto.

Newman's Blowpipe, 1816.

Gurney's oxy-hydrogen Blowpipe, 1823.

DISTILLATION

Retorts of Berlin Porcelain, with loose heads; ditto of Yellow-glazed Stoneware made by *J. Wedgwood*; ditto of Green Glass, tubulated; French Fireclay 'de la Fabrique d'Orleans'.

Pear-shaped Bodies of Clear Glass with ∽-shaped receiver of thin glass.

Globular Receivers, Adapters, Alembics, *c.* 1793.

Apparatus for Fractional Distillation, with Woulfe's bottle. Cf. *Phil. Trans.*, 1767.

Ditto, known as the '**Hydra**' with vertical recipients.

Compound Distillatory Apparatus of Hassenfratz, *c.* 1793. The glass tubes in the middle necks of the bottles were suggested to Lavoisier by Hassenfratz as a means of avoiding disaster due to water in the cistern of the pneumato-chemical apparatus rushing back into the last bottle whenever a diminution of the heat of the furnace occurs.

Preparation of Gases

Dr. Priestley's Apparatus for collecting the elastic fluids which are evolved when metals dissolve in acids with effervescence.

Lavoisier's Apparatus for Metallic Dissolutions, *c.* 1793. Note the glass rod fitted with emery in the funnel, so as to serve as a stopper.

Graduated Gas Tubes.

Eudiometers.

Analytical Apparatus

Test Glasses: Conical; conical without stem; Clark's conical pattern with stem.

Dropping Bottle for acidimetry and alkalimetry.

Marsh's Arsenic Test Apparatus.

The inventor was also the inventor of a time-fuse for shells.

Sir H. Davy's Carbonic Acid Apparatus for estimating lime in soils, 1814. When the stop-cock is turned, muriatic acid flows into the generator containing the soil; the CO_2 generated expands a bladder, so displacing an equal quantity of water which is measured in a measuring glass. For every ounce of water, 2 grains of carbonate of lime in the soil are indicated.

Davy Lamps.

Another early relic is a Set of **Cup Weights** used by Dr. Robert Bourne, Reader of Chemistry, presented by his grandson, Professor G. C. Bourne of New College.

Mayow's Apparatus for study of Respiration and Combustion, 1667. Reproduced from his *Tractatus quinque* of 1647, of which a reprint is available in the *Old Ashmolean Series of Reprints.*

Views of Chemical Laboratories, etc.

Lecture Theatre of the Royal Institution with Humphrey Davy assisting the lecturer, who is administering laughing gas. Caricature by Gillray 1802.

The Surrey Institution. 1810.

LIBRARIES

The **Old Ashmolean Library** given by the founder and his friends is described on p. 17.

The Ashmolean **Chemical Library** formed by Dr. Plot as a departmental library has also been moved from the building.

The **Evans Library** comprises about a thousand volumes relating to scientific instruments, astronomy and dialling, of which some forty are in manuscript; many have special association-value. The more valuable part of the collection is arranged in a glazed book-case that was originally made for the palace at Blenheim.

A few books and manuscripts are on exhibition in the centre cases.

Cabinets of Drawers are contained in parts of the **Collection of Manuscripts** and **Engravings,** that are not at present exhibited.

Nicolas Kratzer, Portrait by Holbein and manuscript description of a polyhedral dial resembling the one made for Cardinal Wolsey. (Photographs.) It is probable that he designed the dials painted by Holbein in the well-known picture of *The Ambassadors.*

He was admitted to the new college of Corpus Christi in 1517. His duty was to lecture on astronomy and mathematics as Wolsey Lecturer; later he became 'deviser of the King's horologies'.

James Ferguson, F.R.S., 1710–76, the self-taught astronomer who mapped the stars while

tending sheep. Portrait and original Nocturnal with autograph description, and **Solar Time-finder** in the latitude of Bungay.

Albert Durer, *Treatise on Geometry* showing the utility of that art in the construction of beautiful lettering. His original work was printed in 1525, three years before he died.

Robert Recorde of All Souls College. Photograph of portrait.

His invention, the **sign of equality** =.

Thomas Hariot *b.* in St. Mary's Parish.

His invention, the **signs of inequality** < and >.

Examples of **Arabic Numerals** of various periods.

Johannes Stöffler, *Treatise on the Astrolabe and on Surveying* 1512.

Stöffler, 1452–1531, was also the author of *Calendars* that attained to a wide circulation; indeed our Nautical Almanack is their lineal descendant. Such trust was placed in his prognostications that when his aspects of the heavens told him that in the year 1524 three planets would meet in the aqueous sign of Pisces, he terrified Europe by predicting a universal deluge. President Aurial of Toulouse even went so far as to build a Noak's Ark for himself. Unluckily 1524 turned out disastrous by reason of drought!

Among his pupils was Sebastian Munster, writer on clocks and dials.

Miscellaneous **Portraits of Men of Science.** Duplicates from the Hope Collection lent by the Keeper and Curators.

Among the more recent association books are :

Ashmole's *Order of the Garter, Theatrum Chemicum,* and *Diary,* all presented by the representative of his family, Professor Bernard Ashmole.

Books of **W. Molyneux,** who as Secretary of the Dublin Society, corresponded with the Oxford Philosophical Society between 1683–90.

Rev. **Lewis Evans,** F.R.S., of Merton College, Lecture Manuscripts, when first instructor in scientific and mathematical subjects at the Royal Military Academy, Woolwich in 1799, from his great-grandson, Dr. Lewis Evans.

Books from the Library of **Isaac Newton,** Lent by R. T. G.

The first **Chemical Library** of the University, is represented by the presentation copy of Plot's *Natural History of Oxfordshire,* which afterwards passed into the possession of John Aubrey, and of New Inn Hall. Lent by R. T. G.

Other books of this departmental library, are in the Bodleian.

PUBLICATIONS

It is practically certain that Oxford owes the Old Ashmolean Collections and Museum to the fact that Dr. Robert Plot had in 1676 produced that excellent book, the *Natural History of Oxfordshire.* A University with so competent and patriotic a natural historian was clearly the place for the Tradescant-Ashmole Museum of Natural History, and certainly it was on that account too that John Evelyn first recommended Plot to Ashmole in 1677, as a fit and proper Keeper for the Museum. A second edition of the *Natural History* appeared in 1705, nine years after Plot's death.

After the opening of the Museum, Plot published a small treatise on the origin of springs, *De Origine Fontium,* which he dedicated to Ashmole, giving him a presentation copy on 19 November, 1684. This was the first publication from the new Institution. In his new office Plot continued to consider the predilections of his patron, and undertook a second large work on Ashmole's native county, *The Natural History of Staffordshire,* delivering a copy on 23 May, 1686.

And lastly, as a further act of piety Plot copied out the manuscript *Diary and Letters of Elias Ashmole,* which were afterwards edited and printed by Burman in 1717.

The second Keeper, Edward Lhwyd, devoted much energy to a Catalogue of Fossils in the Museum, most of which he had obtained himself, with engravings of many which had not been pre-

viously described. It was pioneer work of great value, but the University declined to print it, and Lhwyd was compelled to seek financial aid from his friends, Sir Isaac Newton, Sir Hans Sloane, and others, and so succeeded in getting 120 copies printed in 1699 under the title *Lithophylacii Britannici Ichnographia.* 1700 species and varieties of formed stones are described therein, and it was reprinted by William Huddesford in 1760.

And in 1770 under the same editorship the second edition of the *Historiae sive Synopsis Methodicae Conchyliorum et Tabularum Anatomicarum* of Dr. Martin Lister to which were added *Duo Indices,* the first according to the classification adopted by Lister and the second according to the new System of Linnaeus. These indexes he dedicated to Margaret Cavendish, Dowager Duchess of Portland.

John Aubrey, *Lives of* [*the Mathematicians*] *Eminent Men now first published from the original MSS. in the Ashmolean Museum.* 1813.

For a century and a third no Keeper after Lhwyd attempted to publish any original catalogue of the Collections, but in 1836 Philip Duncan issued a *Catalogue of the Ashmolean Museum descriptive of the Zoological Specimens, Antiquities, Coins and Miscellaneous Curiosities.*

Proceedings of the Ashmolean Society, vol. i, 1832–42; vol. ii, 1842–53; vol. iii, 1853–March 1858.

Transactions of the Ashmolean Society, vol. i, 1835–8; vol. ii. 1838–53.

Black, W. H. *A descriptive Catalogue of the Manuscripts bequeathed by Elias Ashmole, also of some additional MSS. contributed by Kingsley, Lhwyd, Borlase, and others.* 1845.

Strickland, H. E., President of the Ashmolean Society. *The Dodo and its Kindred.* 4to. 1848.

Since the reopening of the Museum in 1925, the following works and notes have been published:

Historic Instruments for the Advancement of Science: a handbook to the Oxford Collections prepared for the opening of the Lewis Evans Collection on 5 May, 1925.

Series of Picture Postcards:

Great Inventors.
Men of Science of the XVIIth Century.
History of Mathematics.
History of Medicine.
The Dodo.
Views of the Old Ashmolean Building.

C. F. Jenkin, *The Oxford Astrolabe.*

The Old Ashmolean and the Lewis Evans Collection of Scientific Instruments, pp. 328–36 of J. J. Walker's *Natural History of the Oxford District,* 1926.

The Evans Collection at Oxford: Six Centuries of Progress. The Times, 3 August, 1926.

The Astrolabes and Dials of Humphrey Cole of London. Illustrated London News, 14 August, 1926.

Richard of Wallingford and his Rectangulus. Nature, 27 November, 1926.

The Great Astrolabe and other Scientific Instruments of Humphrey Cole. Archaeologia, vol. 76.

The Astrolabe: its use and derivatives. Scottish Geographical Magazine, vol. 43.

Richard Dyer, 1651–1730. Botanical Magazine, February, 1926.

The Mariner's Astrolabe. Geographical Journal, 1928.

Chaucer and Messahalla on the Astrolabe, now printed for the first time with the original illustrations. Early Science in Oxford, vol. v, 1929.

John Evelyn, *Fumifugium.* Old Ashmolean Reprints, vol. 8.

The Life and Work of Robert Hooke. Early Science in Oxford, vols. vi and vii.

Touchstone's Dial. The Times Literary Supplement, 17 January, 1929.

Mass Dials. The Times, 12 April, 1929.

The Oldest Public Chemical Laboratory. Daily Telegraph, 15 May, 1929.

Articles *Astrolabes* and *Dialling.* Encyclopaedia Britannica.

Uranical Astrolabe and other Inventions of John Blagrave of Reading. Archaeologia, vol. 79.

Great Oxford Pioneers of Science and Industry of the XVIIIth century. Ashmolean Natural History Society of Oxfordshire, Report for 1929.

Dr. Lewis Evans, An Appreciation. Nature, 1 November, 1930.

The Cutler Lectures of Robert Hooke. Early Science in Oxford, vol. viii. 1931.

Chaucer on the Astrolabe. 2nd edition.

The Ashmole Printed Books
The Chemical Library of the University
The Library of John Aubrey, F.R.S.
} Bodleian Quarterly Record, vi.

The Astrolabes of the World. 2 vols. 4to. 1932.

Annual Reports of the Committee of Management of the Lewis Evans Collection. Oxford University Gazette, 1925 to 1933 et seq.

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The above may be obtained of Dr. R. Gunther, at the Old Ashmolean, Oxford.